DEPARTMENT OF TRANSPORTATION
DES-OE MS #43
1727 30TH Street, 2ND Floor
Sacramento, CA 95816

November 19, 2003

04-SF-80-13.2/13.9
04-0120F4
ACBRIM-080-1(095)N

Addendum No. 16

Dear Contractor:

This addendum is being issued to the contract for construction on State highway in SAN FRANCISCO COUNTY IN SAN FRANCISCO FROM 0.6 KM TO 1.3 KM EAST OF THE YERBA BUENA TUNNEL EAST PORTAL.

Submit bids for this work with the understanding and full consideration of this addendum. The revisions declared in this addendum are an essential part of the contract.

Bids for this work will be opened on January 21, 2004.

This addendum is being issued to revise the Project Plans, the Notice to Contractors and Special Provisions, and the Proposal and Contract.

Project Plan Sheets 409, 410, 435, 436, 437, 439, 454, 460, 466, 474, 475, 476, 477, 494, 495, 496, 497, 505, 508, 509, 535, 553, 554, 558, 559, 568, 573, 574, 576, 582, 585, 591, 595, 596, 603, 612, 614, 615, 620, 630, 638, 643, 644, 646, 651, 653, 654, 656, 661, 678, 691, 701, 708, 712, 715, 716, 721, 743, 757, 770, 773, 774, 777, 778, 797, 803, 806, 848, 849, 857, 911, 919, 967, 1033, and 1091 are revised. Half-sized copies of the revised sheets are attached for substitution for the like-numbered sheets.

Project Plan Sheets 75A and 75B are added. Half-sized copies of the added sheets are attached for addition to the project plans.

In the Special Provisions, "IMPORTANT SPECIAL NOTICES," the following notice is added:

"A meeting to address bidder's technical inquiries will be held on December 16, 2003 at 9:00 a.m. (Pacific Time) in the Auditorium, District 4 Office, 111 Grand Ave, Oakland, CA 94612. The purpose of the meeting is to provide preliminary answers to bidder's technical inquiries. Prospective bidders unable to attend in person may dial the teleconference call-in number 510-286-2230. The call leader is Brian Maroney.

Bidders who are participating in this meeting may submit their questions in writing to the Duty Senior at the District 4 Office, 111 Grand Avenue, Oakland, California 94612, Fax number: (510) 622-1805, e-mail address: duty_senior_district04@dot.ca.gov, telephone: (510) 286-5209, no later than 4:00 p.m. on December 10, 2003. The written inquiry should clearly identify the bidder's identity and the contract specification(s) or drawing(s) that form the basis for the question. Each question should be separately numbered.

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To the extent feasible and at the discretion of the Department, an oral response will be provided to each written question. A technical panel will be available to review the inquiries, request further information from the bidder, and then provide preliminary feedback to the bidder. The Department's final written response to each question will be made available to all bidders in accordance with the bidder inquiry provisions of the Notice to Contractors. Bidders are cautioned that oral responses and instructions given at the meeting are not binding on the Department."

In the Special Provisions, Section 5-1.35, "RELATIONS WITH SAN FRANCISCO BAY CONSERVATION DEVELOPMENT COMMISSION," the fifth paragraph is revised as follows:

"For work already authorized in the BCDC permit, the Contractor shall submit to the Engineer a plan for in-Bay docks, trestles, and temporary structures, including temporary towers and falsework within 15 working days after the approval of the contract, or six months prior to beginning construction of in-Bay docks, trestles, and temporary structures, including temporary towers and falsework, whichever is later. The plan shall include the area covered by the in-Bay temporary structures, docks, and trestles and volume of water displaced by the in-Bay temporary structures, docks, and trestles to be placed Bayward of the mean-high-water-line. The Engineer will submit to BCDC for final plan review; the Engineer and BCDC will review and the Engineer will provide comments to the Contractor within 50 working days. The Contractor will have 10 working days to revise and resubmit."

In the Special Provisions, Section 5-1.365, "RELATIONS WITH SAN FRANCISCO BAR PILOTS," is added as attached.

In the Special Provisions, Section 8-1.03, "STATE-FURNISHED MATERIALS (PENDING STRUCTURE/PB)," the following item is added to the list in the second paragraph as follows:

"K. Three metal benches for East-end belvedere of bikepath"

In the Special Provisions, Section 8-1.03, "STATE-FURNISHED MATERIALS (PENDING STRUCTURE/PB)," the following paragraph is added after the third paragraph as follows:

"Metal benches will be furnished to the Contractor at the warehouse of Pier 7, 315 Dunkirk Street, Oakland, CA 94607.

In the Special Provisions, Section 8-4.01, "AUDITS," the fourteenth paragraph is revised as follows:

"Should the manufacturer or fabricator fail the second Department audit after having failed the first Department audit, an additional deduction per re-audit shall apply for the greater of $22,000 or $.04 per kilogram of steel produced at that facility, not to exceed $45,000."

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In the Special Provisions, Section 10-1.01, "ORDER OF WORK," the sixth paragraph is revised as follows:

"The State will furnish to the Contractor working drawings and a steel template for the as-fabricated tower footing for locating the holes in the tower base plate for the tower anchorage anchor bolt pipe sleeves and the dowels no later than May 1, 2006, in accordance with the requirements in "STEEL STRUCTURES," subsection "TEMPLATE," of these special provisions."

In the Special Provisions, Section 10-1.10, "TRANSPORTATION FOR THE ENGINEER," the second paragraph is revised as follows:

"The Contractor shall provide, operate, berth and maintain, beginning with the first mobilization of marine equipment until contract completion, one crew boat for the sole use of the Engineer and the Engineer's staff in performance of their work. In addition, the Engineer and all authorized representatives of the State, acting within the scope of their duties in connection with the work under this contract, shall be permitted to ride as passengers, without charge, on any boat operated by, or for, the Contractor for the transportation of personnel, equipment or materials. It is agreed that such transportation will be only on the boats that are making trips in connection with the Contractor’s operation."

In the Special Provisions, Section 10-1.10, "TRANSPORTATION FOR THE ENGINEER," the seventh paragraph is revised as follows:

"The Contractor shall furnish a licensed boat operator and crew members, as required for the boat’s operation and in accordance with all Maritime Agreements and Laws, including, but not limited to, the regulations contained in Title 46 Code of Federal Regulation Section 16 and Sections 24 through 26. The boat must have a valid U.S. Coast Guard Certificate of Inspection (COI), and must be manned and operated in accordance with the COI. The boat, boat operator and crew shall be furnished beginning with the first mobilization of marine equipment until contract completion for the duration of the contract. The boat, boat operator and crew shall be furnished for the complete duration of the work on the days when the Contractor’s work is in progress and for 8 hours each day excluding Sundays and legal holidays on the days when the Contractor’s work is not in progress."

In the Special Provisions, Section 10-1.10, "TRANSPORTATION FOR THE ENGINEER," the thirteenth paragraph is revised as follows:

"Payment for furnishing a boat, boat operator and crew prior to the times specified and in excess of the complete duration of the work on the days when the Contractor’s work is in progress, in excess of 8 hours per day and on Sundays and legal holidays when the Contractor's work is not in progress will be paid for as extra work as provided in Section 4-1.03D of the Standard Specifications. No additional payment will be made for furnishing the boat, boat operator and the crew in excess of the time specified herein."

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In the Special Provisions, Section 10-1.19, "CONSTRUCTION SURVEYING," the thirteenth paragraph is deleted.

In the Special Provisions, Section 10-1.40, "CONCRETE STRUCTURES," subsection "FALSEWORK," the following paragraph is added before the first paragraph:

"The Contractor shall remove forms within the W2 cap beam to the limits shown on the plans."

In the Special Provisions, Section 10-1.46, "SEALING JOINTS," is revised as attached.

In the Special Provisions, Section 10-1.47, "POLYESTER CONCRETE OVERLAY (13MM)," subsection "CONSTRUCTION," the first paragraph is revised as follows:

"Prior to constructing the overlay, one or more trial overlays shall be placed on a previously constructed steel plate to determine the initial set time and to demonstrate the effectiveness of the mixing, placing, and finishing equipment proposed. Each trial overlay shall be 3.6-m wide, at least 1.8-m long, and the same thickness as the overlay to be constructed. Conditions during the construction of the trial overlays and equipment used shall be similar to those expected and those to be used for the construction of the polyester concrete overlay."

In the Special Provisions, Section 10-1.47, "POLYESTER CONCRETE OVERLAY (13MM)," subsection "CONSTRUCTION," the seventh paragraph is revised as follows:

"Expansion joints shall be adequately isolated prior to overlaying, as approved by the Engineer. Prior to applying the prime coat, the area to receive the prime coat shall be dry and blown clean by compressed air to remove accumulated dust and any other loose material. The surface temperature shall be at least 10°C and the relative humidity less than 85 percent when the prime coat is applied."

In the Special Provisions, Section 10-1.51, "STEEL STRUCTURES," is revised as attached.

In the Special Provisions, Section 10-1.52, "CABLE SYSTEM," subsection "MATERIALS AND FABRICATION," subsection "Shop Prefabricated Parallel Wire Strand (PWS)," the first sentence of the fifth paragraph is revised as follows:

"Each end of the strand shall be socketed with zinc or zinc-copper alloy."

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In the Special Provisions, Section 10-1.52, "CABLE SYSTEM," subsection "MATERIALS AND FABRICATION," subsection "Shop Prefabricated Parallel Wire Strand (PWS)," the sixth paragraph is revised as follows:

"The Contractor shall submit the strand socket details and socketing procedure specification, which is proposed as the standard of his operation. The Contractor shall submit a strength test procedure to the Engineer for approval. The procedure shall consist of tensioning the assembly of strands, sockets, and strand anchor rods. The Contractor shall prepare five specimens in accordance with the stated procedure. The specimen shall then be strength tested as follows:

A. The load shall be increased at a slow rate as approved by the Engineer up to 50% of the breaking strength. The Contractor shall keep records of load and elongation for at least 15 load points, if not continuously. While the loading is stopped, measure the extent that the cones have pulled through the mouth of the socket (pull-out).
B. The load shall be continued to failure. The load deformation shall be recorded by recording the distance between the sockets with each load, until the strand reaches the ultimate strength."

In the Special Provisions, Section 10-1.52, "CABLE SYSTEM," subsection MATERIALS AND FABRICATION," subsection "Suspender Ropes," the first sentence of the third paragraph is revised as follows:

"The Contractor shall prepare and submit to the Engineer suspender socket details and a socketing procedure, which shall be tested and witnessed by the Engineer."

In the Special Provisions, Section 10-1.52, "CABLE SYSTEM," subsection "MATERIALS AND FABRICATION," subsection "Suspender Ropes," the fifth paragraph is revised as follows:

"Each specimen shall be loaded to failure and slip (pull-out of rope) shall be measured. During the test, the assembly of suspender, socket, and socket anchor rods shall be tensioned. A record shall be kept of load deformation up to the value where the rope deformation deviates from a linear behavior. The modulus of elasticity shall be measured at service load for each of the five specimens."

In the Special Provisions, Section 10-1.62," CLEAN AND PAINT STRUCTURAL STEEL," is revised as attached.

In the Special Provisions, Section 10-1.64," CLEAN AND PAINT CABLE SYSTEM," is revised as attached.

In the Special Provisions, Section 10-1.68, "MISCELLANEOUS METAL (BRIDGE)," the following paragraph is added after the second paragraph:

"Attention is directed to "NONSKID SURFACE" of these special provisions."

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In the Special Provisions, Section 10-1.70, "NONSKID SURFACE," the first paragraph is revised as follows:

"Where shown on the plans, steel plates and ladders shall receive a nonskid surface consisting of epoxy mixed with grit. Epoxy shall conform to the provisions in Section 95, "Epoxy," of the Standard Specifications."

In the Special Provisions, Section 10-1.70, "NONSKID SURFACE," the eighth paragraph is revised as follows:

"Full compensation for furnishing and placing nonskid surface shall be considered as included in the various contract items involved and no separate payment will be made therefor."

In the Special Provisions, Section 10-3.16, "SUPERVISORY CONTROL AND DATA ACQUISITION REMOTE TERMINAL UNIT SYSTEM," is revised as attached.

In the Proposal and Contract, in the Engineer's Estimate, Alternative 1 and Alternative 2, Items 45, 46, 47, and 48 are revised as attached.

To Proposal and Contract book holders:

Replace pages 30 and 38 of the Engineer's Estimate in the Proposal with the attached revised pages 30 and 38 of the Engineer's Estimate. The revised Engineer's Estimate is to be used in the bid.

Indicate receipt of this addendum by filling in the number of this addendum in the space provided on the signature page of the proposal.

Submit bids in the Proposal and Contract book you now possess. Holders who have already mailed their book will be contacted to arrange for the return of their book.

Inform subcontractors and suppliers as necessary.

This office is sending this addendum by UPS overnight mail to Proposal and Contract book holders to ensure that each receives it. A copy of this addendum and the modified wage rates are available for the contractor's use on the Internet Site:

http://www.dot.ca.gov/hq/esc/oe/weekly_ads/addendum_page.html

If you are not a Proposal and Contract book holder, but request a book to bid on this project, you must comply with the requirements of this letter before submitting your bid.

Sincerely,

ORIGINAL SIGNED BY JEFF L DeFEVERE FOR:

REBECCA D. HARNAGEL, Chief
Office of Plans, Specifications & Estimates
Office Engineer

Attachments

5-1.365 RELATIONS WITH SAN FRANCISCO BAR PILOTS

This project is located in the Bay of San Francisco, in which shipping vessels are under the jurisdiction of the San Francisco Bar Pilots. Attention is directed to Division 5, "Pilots for Monterey Bay and the Bays of San Francisco, San Pablo, and Suisun" of the California Harbors and Navigation Code.

Full compensation for conforming to the requirements of the San Francisco Bar Pilots shall be considered as included in the contract prices paid for the various contract items of work and no additional compensation will be allowed therefor.

10-1.46 SEALING JOINTS

Joints between columns at Pier W2 and concrete cover slabs, and joints in the bikepath overlay shall be sealed in conformance with the details shown on the plans, the provisions in Section 51, "Concrete Structures," of the Standard Specifications, and these special provisions.

Where polyurethane seals are shown on the plans, a silicone sealant conforming to the provisions in Section 51–1.12F, "Sealed Joints," of the Standard Specifications may be used.

When ordered by the Engineer, a joint seal larger than called for by the Movement Rating shown on the plans shall be furnished and installed. Payment to the Contractor for furnishing the larger seal and for saw cutting the increment of additional depth of groove required will be determined as provided in Section 4-1.03, "Changes," of the Standard Specifications.

Full compensation for sealing joints shall be considered as included in the various contract items involved and no separate payment will be made therefor.

10-1.51 STEEL STRUCTURES

Construction of steel structures shall conform to the provisions in Section 55, "Steel Structures," of the Standard Specifications and these special provisions.

Fabricators and suppliers shall be certified under the AISC Quality Certification Program, Category Cbr, Major Steel Bridges, with endorsement F, Fracture Critical members.

Details of box girder and crossbeam connections shall conform to the AASHTO Standard Specifications for Highway Bridges, unless otherwise shown on the plans.

Attention is directed to "Accelerated Working Drawings Submittal," of these special provisions.

The bikepath shall be considered part of the bridge and not an ancillary structure.

GENERAL

Attention is directed to “Construction Surveying,” of these special provisions.

Attention is directed to "Progress Schedule (Critical Path Method)" of these special provisions.

Attention is directed to “State-Furnished Materials,” of these special provisions regarding pipe beam restraint brackets.

Attention is directed to “Prestressing,” of these special provisions for post-tensioning provisions within the box girder.

Attention is directed to "Welding" and “Audits” in Section 8, "Materials," of these special provisions.

Members shown on the plans with Seismic Performance Critical Member (SPCM) designations, including welds connecting SPCMs to other members shall conform to the requirements in ANSI/AASHTO/AWS D1.5, Section 12, "AASHTO/AWS Fracture Control Plan (FCP) for Non-Redundant Members" as modified herein.

DEFINITIONS

"Box girder" is defined as the two suspended roadway structures, including all internal structures.

"Orthotropic deck" is defined as the top plate of the box girder along with the ribs.

"Segment" is defined as a structural subassembly that has the full cross section of the tower shaft, box girder or cross beam, but is smaller than a lift.

"Lift" is defined as a structural subassembly that is field erected.

“Suspended structure” is comprised of the box girder, crossbeam and bikepath. The weight of the suspended structure is defined as the weight of the box girder, crossbeam, and bikepath, as well as the weight of the cable system, pipe beams, deck overlay, utilities, platforms, barrier counter weight, and all other components that contribute to the superstructure weight.

The "Seismic Performance Critical Member" ("SPCM") designation identifies structural elements, including welds connecting SPCMs to other members, that are critical to the seismic performance of the bridge and that are fabricated and inspected to the requirements of AWS D1.5, Section 12, as modified by these special provisions.

WORKING DRAWINGS

Attention is directed to “Working Drawings,” elsewhere in these special provisions.

Section 55-1.02 “Drawings,” of the Standard Specifications shall not apply.

Working drawings shall contain all information required for the fabrication of structural steel, including, at a minimum, the following:

1. Design geometry lines and fabrication geometry working lines, including vertical, longitudinal and transverse. Each working drawing shall reference the Contract Plan sheet(s) from which fabricable dimensions are derived;
2. Panel, segment and lift designations, erection sequence and locations of field connections;
3. Details of temporary fabrication in plan, elevation and section, material specification and grades, weld details and all tolerances;

4. Details of permanent fabrication in plan, elevation and section, material cuts and camber deformations, and tolerances of the fabricated panel structure. The scale of each panel plan and section shall not be less than 1: 50. Full detail scales shall be larger;
5. Material and weld designations including the ASTM material specification, processes of shop fabrication including forming, heat treating and welding, weld symbols as required by AWS D1.5, and for each weld, either the "Joint Designation" as listed in figures 2.4 or 2.5 of AWS D1.5 or the WPS number for non-standard joints;
6. Distortion control plan in accordance with AWS D1.5, Section 3.4;
7. Details of shop and field welding, and shop and field-drilled holes for all ancillary attachments to the box girder, crossbeam, tower, and pipe beams.

Supplemental calculations shall include, but not be limited to, the following:

A. Calculations for each panel showing how the camber for extension, angular change and profile affects the cutting and assembly of the plate material.

For box girder, crossbeam, tower, and pipe beam fabrication, shop practices shall be described in the working drawings and shall include the following:

A. Method of rib or pipe beam fabrication, including forming, bending, equipment, and procedures;
B. Details of fabrication jigs and measurement templates (orthotropic box girder only);
C. Lifting points and support details;
D. Details of temporary lugs or brackets and methods of handling large elements;
E. Details of tack welds and the sequence of all welding; The welding sequences and processes and specified NDT of shop fabrication shall be summarized in a separate shop drawing or fabrication procedure for each welded joint.
F. Details of removal of temporary connections and repair of material where these connections were installed;
G. Methods of repair of elements that exceed specified tolerances; and
H. Fabrication schedule.

The Contractor shall allow the Engineer 30 working days to review the structural steel working drawings if the submittal is 120 pages or less. If the submittal is greater than 120 pages the review time shall be 35 working days.

TEMPLATE

The State will furnish to the Contractor working drawings for the as-fabricated tower footing, in accordance with "Order of Work" of these special provisions. Working drawings shall include the following:

A. A plan view of the tower footing at Elevation 3.00m of sufficient scale showing the labeled location of the following items:

    1. As-fabricated tower anchorage anchor bolt pipe sleeves
    2. As-fabricated tower anchorage anchor bolts
    3. As-fabricated dowels

B. A summary of locations and corresponding coordinates of the following items in tabular form using the Global Positioning System (GPS) consistent with the requirements of "Construction Surveying" of these special provisions. Coordinates shall be provided for the following elevations:

    1. As-fabricated tower anchorage anchor bolt pipe sleeves. Elevation 3.00m
    2. As-fabricated tower anchorage bolts. Elevation 3.00m and Elevation 5.50 m (approximate top of tower anchorage anchor bolts)
    3. As-fabricated dowels. Elevation 3.00m and 3.24m

C. Location and coordinate summaries segregated by item type.

The State will furnish to the Contractor a steel template with holes that correspond to the as-fabricated location of the tower anchorage anchor bolt pipe sleeves and dowels, in accordance with "Order of Work" of these special provisions. The steel template will be comprised of four (4) match-marked pieces or as otherwise furnished by the State.

The Contractor shall use the steel template to locate the holes in the tower base plate for the tower anchorage anchor bolts and dowels.

The Contractor shall verify the location of the holes by physically matching the steel template to the tower base plate. The Contractor shall demonstrate that the holes in the tower base plate match the steel template, as witnessed by the Engineer, by physically matching the as-fabricated tower base plate. The Contractor shall notify the Engineer at least 7 working days prior to matching the steel template.

Prior to erecting the tower base, the Contractor shall field verify the as-built location of the tower anchorage anchor bolts and dowels, by physically lowering the steel template onto the pile cap, as witnessed by the Engineer. Lowering of the template shall be done in the same manner and same number of pieces that are planned for setting the tower base plate. The Contractor shall notify the Engineer at least 7 working days prior to the fitting of the steel template.

FALSEWORK

Falsework and attachments used for the erection of structural steel shall be fabricated in accordance with AWS D1.1, Section 55-1.05 “Falsework,” of the Standard Specifications and the requirements for Falsework in “Concrete Structures,” of these special provisions, except that dead loads shall consist of the mass of the structural steel and any other portions of the structure which are supported by the falsework.

The seismic and wind load design requirements for falsework, connections, and permanent structures during construction shall conform to "Temporary Towers," of these special provisions.

ERECTION PLAN

The Contractor shall submit working drawings and supplemental calculations for the erection of structural steel in accordance with the requirements in “Working Drawings,” of these special provisions.

The bridge is designed as a completed structure to carry loadings from permanent service conditions and seismic events. Temporary construction loading was not considered in the design. The Contractor shall perform construction engineering to ensure temporary construction loading does not overstress any part of the permanent structure at any stage of construction.

The Contractor shall develop a preliminary erection plan prior to submitting the erection plan. The preliminary erection plan shall include the following:

A. The sequence and limits of segments to be erected.
B. Proposed attachment locations for transportation and lifting of each section.
C. Methods for transportation and lifting of each section.
D. Methods for aligning adjacent sections during erection.
E. Locations of temporary supports and reinforcing.
F. Methods for dimensional checks.
G. Methods for analyzing the box girders and crossbeams for moments, stresses, deflections, and cambers throughout the proposed erection sequence.
H. Methods for analyzing the suspension system for deflections and tensions throughout the proposed erection sequence.
I. Milestone date when updates to the Hinge A (Contract No. 04-012024) and Hinge K (Contract No. 04-0120P4) reactions are required to finalize camber values for PP95 to Hinge A. This milestone shall be included in the Contractor's Progress Schedule. The Contractor shall demonstrate to the Engineer that this milestone is the controlling operation. At this milestone, the Contractor shall have developed a sufficiently accurate weight estimate in accordance with the approved weight control procedure.

The Contractor shall develop the preliminary erection plan using the reactions from Hinges A and K shown on the plans.

The Engineer will provide the reactions required at the milestone specified in the approved preliminary erection plan and the approved Progress Schedule in the event that these reactions cannot be measured. Reactions provided by the Engineer shall be used by the Contractor for the purposes of fabrication and erection until the reactions can be measured by the Contractor.

The Contractor shall readjust the suspender forces at Panel Points 10, 12, 14, 104, 106, 108, 110, and 112 based on a final erection analysis that includes the measured reactions from Hinges A and K or as directed by the Engineer.

The Contractor's preliminary erection plan shall demonstrate to the Engineer that the Contractor has a sufficient understanding of the structural system and is able to perform all required erection analyses and designs, to adequately detail and fabricate the temporary and permanent structures, and to account for varying conditions due to changes in installed weight, and changes in the specified hinge reactions.

The Contractor shall allow the Engineer 30 working days to review and approve the preliminary erection plan.

Erection of each box girder from Pier W2 to Hinge A shall be completed with a maximum of 20 lifts.

At the option of the Contractor, lifting attachments may be welded or bolted to structural steel to assist in hoisting the load, except as noted herein. Welds attaching these devices shall conform to the requirements of field welding specified herein. Such attachments shall not interfere with the holes shown on the plans. Holes shall not remain in the permanent structure, unless otherwise shown on the plans.

Lifting attachments shall not be attached to the orthotropic deck. For the tower struts, no additional bolt holes will be allowed for temporary works. Tower strut holes may be used in temporary works, as approved by the Engineer. No welding to the tower struts for temporary works will be permitted.

The erection plan shall contain all information required for the erection of structural steel, including, at a minimum, the following:

A. Details and limits of each section to be erected;
B. Details of attachments to each section for transportation and lifting including location, welding and removal procedures;
C. Methods for transportation and lifting of each erected section;
D. Method of aligning adjacent sections during erection;
E. Details of temporary work platforms and other aids required for field welding;
F. Locations and methods for all tack and final welds;
G. Timing and methods for dimensional checks;
H. Timing and methods for visual and nondestructive examination
I. Methods for connection and removal of supports and lifting attachments.
J. Methods for measuring the reactions at Hinge A (Contract No. 04-012024) and Hinge K (Contract No. 04-0120P4). If the measured reactions per box girder exceed 2.25 MN at Hinge A or 1.0 MN at Hinge K, the Contractor shall immediately notify the Engineer in writing. The Engineer may direct the Contractor to make modifications to the erection plan based on the measured reactions. Modifications to the erection plan will be paid for as extra work as provided in Section 4-1.03D, "Extra Work," of the Standard Specifications.
K. Complete details and substantiating calculations of the method and materials the Contractor proposes to use in prestressing high-strength bolts, including the method and sequence of stressing, working stresses and anchoring stresses.

Supplemental calculations shall include, but not be limited to, the following:

A. Calculations indicating the stresses imposed on sections of the permanent structure due to attachments, and stresses imposed during erection, including but not limited to the effects of wind speed, local topography, and adjacent structures.

B. Calculations indicating the stresses imposed on sections of the permanent structure during transportation.
C. Estimates of final dimensions, including camber, based on dimensional measurements during the trial fit under support conditions that differ from those of the in-place condition.

The Contractor shall allow the Engineer 50 working days to review and approve the erection plan.

Attention is directed to the Alternative Camber Method shown on the plans. At the option of the Contractor, the Alternative Camber Method may be used to facilitate early fabrication of the box girder in accordance with the requirements shown on the plans and in this section.

Use of the Alternative Camber Method shall in no way relieve the Contractor from completing the erection plan as specified in these special provisions. The final approved erection plan shall incorporate all conditions of the as-built structure, including the measured reactions at Hinge A and Hinge K, the weight of all material, the fabricated box girder cambers, and the calculated tension and fabricated length of all suspenders and cable strands. The Contractor's final approved erection plan shall include all effects on the suspension system and the box girders from panel 95 to Hinge A resulting from use of the Alternate Camber Method. No additional compensation will be allowed because of the use of the Alternative Camber Method.

After erection, all lifting attachments shall be removed. Removal of welds shall not damage the permanent steel structure materials. All remaining welds shall be ground flush and damaged areas shall be repaired in accordance with the requirements of ANSI/AASHTO/AWS D1.5. Areas of damaged paint shall be cleaned and painted as specified in "Clean and Paint Structural Steel," of these special provisions.

WEIGHT CONTROL

The Contractor shall submit written, detailed procedures to monitor and control the actual weight of the suspended structure during fabrication and construction.

The weight control procedure shall include the following:

A. Methods for determining the installed weight at various stages of the fabrication and erection.
B. Estimated range of error of weight determination for each weight component at each stage.
C. Identification of milestones on the working drawing submittal schedule when actual installed weight components will be determined by quantity calculations of completed fabrication drawings.

The Contractor shall allow the Engineer 20 working days to review the weight control procedure.

Weight reports shall be submitted using a format described in the approved weight control procedure. These reports shall include the weight of all installed components including utilities, platform barriers, counter weight and roadway wearing surfaces including the range of uncertainty in the estimated final weight.

This weight control procedure shall be used in conjunction with the cable erection described in the section "Cable System," of these special provisions. Attention is directed to the allowable range for target dead load moment in the box girder shown on the plans.

PIPE BEAM INSTALLATION

Pipe beams at Hinges AW and AE shall be moved from their temporary supports and installed into their final positions in accordance with the details shown on the plans and in accordance with the requirements of this section.

Pipe beam temporary supports were designed and constructed as part of Contract No. 04-012024.

Working drawings and supplemental calculations for pipe beam temporary supports are included in the Information Handout available to the Contractor as provided for in Section 2-1.03, "Examination of Plans, Specifications, Contract, and Site of Work," of the Standard Specifications.

A pipe beam installation system shall be designed to adequately support the pipe beams without exceeding allowable stresses or damaging the pipe beam or stainless steel cladding.

Welded attachments will only be permitted on soffit plate intermediate T-stiffeners.

Bolted connections will not be permitted on any steel element.

Allowable stresses for timber and steel shall not exceed those listed in Section 51-1.06A(2) "Design Stresses, Loadings, and Deflections," of the Standard Specifications. The Contractor shall submit to the Engineer working drawings and supplemental design calculations for the pipe beam installation system, in conformance with the requirements in "Working Drawings," of these special provisions.

Working drawings for pipe beam installation system shall include the following:

A. Complete details of the pipe beam installation system
B. A step-by-step pipe beam installation procedure including the following:

    1. Method of lifting and installing the pipe beams into final position
    2. Method of supporting the pipe beams during bearing installation

C. A complete description of methods and materials designed to protect the pipe beam stainless steel surface from damage during lifting, installation and support.

A supplement to working drawings shall include the following:

A. Pipe beam installation system design calculations

The Contractor shall allow the Engineer 25 working days for review of pipe beam installation system working drawings and supplemental design calculations.

MATERIALS

Structural steel shall conform to ASTM Designation: A709M with Supplementary Requirement S84 "Fracture-Critical, F, Material; Toughness Testing and Marking" for members shown on the plans as SPCMs, as well as box girder and crossbeam shell plating, as modified below. Supplementary Requirement S83 "Non-Fracture-Critical, T, Material; Toughness Test and Marking" shall be specified for other members, as modified below. Charpy V-notch (CVN) impact values for steel procurement shall be reported on the mill test report and shall conform to ASTM Designation: A 709M for Zone 2 except as stated in this section "Materials."

Material conforming to ASTM Designation: A 709M, Grade 345W or 690W shall not be substituted for ASTM Designation: A 709M, non-weathering steel grades.

The following structural elements shall be made from fully killed material, conforming to the provisions for fine grain practice of ASTM Designation: A 709M:

A. Box girders, including internal floor beams;
B. Crossbeams;
C. Tower struts links; and
D. Pipe beams.

Steel used in the fabrication of the orthotropic deck shall not contain sulfur in excess of 0.01 % by weight.

Steel designated as Pipe Beam Grade 690 on the plans shall conform to the requirements in ASTM Designation: A 709M, Grade 690 with Supplementary Requirement S5, "Ultrasonic Examination"; Supplementary Requirement S84 "Fracture-Critical, F, Material; Toughness Testing and Marking" tested for Zone 3; and Supplementary Requirement S93, "Limitations on Weld Repair (Fracture Critical Material Only)." The steel shall be made using a low nitrogen and low hydrogen practice such as vacuum degassing. The nitrogen content shall not exceed 0.009%. Charpy V-Notch tests for the as-fabricated pipe beam and heat affected zone (HAZ) shall meet 48 joules (J) minimum average, and 38 J minimum individual at –18˚ C. Weld metal shall meet the requirements of AWS D1.5, Table 12.1.

Steel designated as Pipe Beam Grade 485 and Shear Link Grade 485 on the plans shall conform to the requirements in ASTM Designation: A 709M, Grade HPS485W with Supplementary Requirement S5, "Ultrasonic Examination"; Supplementary Requirement S84 "Fracture-Critical, F, Material; Toughness Testing and Marking" tested for Zone 3; and Supplementary Requirement S93, "Limitations on Weld Repair (Fracture Critical Material Only)." Charpy V-Notch tests for the as-fabricated pipe beam tubular and the pipe beam and shear link heat affected zone (HAZ) shall meet 48 joules (J) minimum average at –18˚ C.

Steel designated as Shear Link Grade 345 on the plans shall conform to the following:

A. The steel shall conform to ASTM Designation: A 709M requirements for Fracture Critical Grade 345 with Supplementary Requirement S93, "Limitations on Weld Repair (Fracture Critical Material Only)," as modified herein.
B. The sulfur content shall not exceed 0.01% by weight. The Carbon Equivalent (CE) shall not exceed 0.47%, where CE = C + (Mn)/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15.
C. The steel shall be fully killed and made to fine grain practice in conformance with the requirements in ASTM Designation: A 709M.
D. The steel shall be made using a low nitrogen and hydrogen practice such as vacuum degassing. The nitrogen content shall not exceed 0.009%.
E. The Yield Point or Yield Strength shall be within the range of 345 through 385 Mpa.
F. The ratio of Yield Strength to Ultimate Strength shall not exceed 0.85.
G. The tensile elongation shall be not less than 19% for a 200 mm gauge length specimen or 22% for a 50 mm gauge length specimen.
H. The reduction of area in the tensile test shall be not less than 35%.
I. Charpy V-Notch (CVN) tests for the base plate shall meet 41 J minimum average at – 40° C. CVN test for the as-fabricated heat affected zone and weld metal shall meet the requirements of AWS D1.5, Table 12.1.
J. Tensile and toughness tests shall be performed on a per-plate basis.

Full traceability between the material test report and the final location in the structure shall be maintained for all Shear Link and Pipe Beam grades of steel.

Ducts for prestressing high-strength ASTM Designation: A 354 bolts shall be galvanized Schedule 40 steel pipe conforming to the requirements in ASTM Designation: A 53 or galvanized rigid steel conduit conforming to UL Publication 6 for Rigid Metallic Conduit, unless otherwise shown on the plans.

Galvanizing for rigid steel conduit or steel pipe shall be tested in conformance with the requirements in ASTM Designation: A 239. Adjacent sections of steel conduit or pipe shall be connected with galvanized standard couplings.

Joints in the ducts shall not leak during grouting operations. Tape, clamps or other devices used outside the ducts to prevent leaks shall be removed after grouting and shall become the property of the Contractor.

Grouting of high strength A354 bolts and base plates shall conform to the provisions in Section 50-1.09 "Bonding and Grouting," of the Standard Specifications.

Pourable seals used with structural steel shall conform to the provisions in Section 51-1.12F(3) "Materials and Installation," of the Standard Specifications.

Where shown on the plans, drain pipe and fittings shall be manufactured from high density polyethylene (HDPE) and suitable for transmission of non-potable water. Joints in HDPE pipe shall be butt-fused.

Ducts, fasteners, and grout caps for prestressing ASTM Designation: A354 bolts shall be considered structural steel (bridge).

CHECK TESTING

Structural steel shall conform to the designated ASTM Standard and the check testing requirements of this section.

Check samples shall be furnished for the following:

A. Each heat of maximum thickness of members designated as SPCM, as shown on the plans.
B. One out of each five heats of steel for box girder shell plate and tower skin plate.
C. Each mother plate of Shear Link Grade 345, Shear Link Grade 485, Pipe Beam Grade 485, and Pipe Beam Grade 690.

Steel plates, shapes, or bars containing check samples shall be furnished from the mill with extra length in order to provide for removal of material for check samples at the point of fabrication. Check samples may be cut from either end of the designated plate, shape, or bar.

At the option of the Contractor, check samples may be removed at the rolling mill rather than at the point of fabrication. The sample will be removed from the mill plate that will be stripped by the fabricator to produce the designated plate and may be taken from any location within that plate. The mill plate from which samples are removed shall be marked with the same identifying numbers as are used on the samples.

Material for check samples shall be removed by the Contractor in the presence of the Engineer. Check samples for plates wider than 610 mm shall be 355 mm wide and 460 mm long with the long dimension transverse to the direction of rolling. Check samples for all other products shall be 460 mm long, taken in the direction of rolling, and the width shall be the product width. Check samples shall be removed and delivered to the Engineer before the material is fabricated into components. The direction of rolling, heat numbers, and plate numbers shall be marked on the samples with paint or other indelible marking material or may be steel stamped in one corner of the plate. Certified Material Test Reports complying with the requirements in these special provisions shall accompany the check sample.

Check samples shall be delivered to the Transportation Laboratory at the Contractor's expense. The check samples will be tested by the Transportation Laboratory for compliance with the requirements specified in ASTM and these special provisions. Check sample test results will be reported to the Contractor within 3 weeks of delivery to the Transportation Laboratory. In the event several samples are submitted on the same day, an additional day will be added for every 2 samples submitted. The test report will be made for the group of samples.

The results of the tensile and impact tests shall not vary more than 5 percent below the specified minimum or 5 percent above any specified maximum requirements. If the initial check test results vary more than 5 percent but not more than 10 percent from the specified requirements, a retest may be performed on another sample from the same heat and thickness. The results of the retest shall not vary more than 5 percent from the original specified requirements. If the results of check tests exceed these permissible variations, material planned for use from the heat represented by said check samples shall be subject to rejection.

THROUGH-THICKNESS QUALITY

Where through-thickness quality steel is shown on the plans, the steel shall meet the low sulfur and reduction of area requirements of AWS D1.5, Section 12.4.4.1. Additionally, each plate shall be ultrasonically examined and shall meet the acceptance criteria in conformance with the requirements in ASTM Designation: A578, Level C. At the option of the Contractor, through-thickness quality steel may be specified at any additional location at no additional cost to the State.

CASTINGS

Castings shown on the plans as "Structural Casting Grade 345," "Structural Casting Grade 415," and "Structural Casting Grade 550" shall conform to the requirements of these special provisions. Castings for suspension, hangar and other cable system components shall conform to the requirements in "Cable System" of these special provisions.

At the option of the Contractor, the remaining portions of the casting components may be redesigned as castings in accordance with the requirements of this section. Any use of castings for other structural components shall follow the requirements of this section, and a detailed, written proposal shall be submitted to the Engineer for prior approval. The Contractor shall submit for the approval of the Engineer, working drawings for castings in accordance with the requirements of "Working Drawings," of these special provisions. Working drawings for castings shall include, at a minimum, detail drawings of the redesigned cast configuration showing equivalency to the details shown on the plans.

The Contractor shall perform finite element complex heat flow analysis for each pattern including all risers and gates that demonstrates that final solidification will occur outside of the final casting. This analysis shall also be used to confirm inspection procedures by identifying the locations of likely defects such as shrinkage, hot tears and porosity. The analytical solid model shall be sufficiently detailed and accurate to demonstrate complete coverage of ultrasonic examination by including the ability to superimpose ultrasonic beam paths on the model. Coverage may be demonstrated by drawing beam paths on printed sections of the solid model. The analytical model and supporting calculations shall be submitted to the Engineer for approval in accordance with the "Working Drawings" section above.

The Contractor shall submit a manufacturing procedure to the Engineer for approval that shall specify all chemical, heat treatment, testing, visual and nondestructive inspection and quality control requirements. Quality control requirements and manufacturing facilities shall be subject to a quality audit as specified in Section 8-4 "Steel Audits" of these special provisions and include the additional requirements of this section.

Castings shall be manufactured to the requirements in ASTM Designation: A148 with the following Supplementary Requirements as modified herein: S1, S4, S5, S6, S7, S8 (Individually marked), S9, S12, S15 (S15.3.2, except one test coupon shall be 3T by 3T by T for all T as described below), and S16.

The manufacturing procedure shall define the specific chemistry, including tolerances for each element. The alloy shall conform to the general limits in the following table, except alternative alloys that meet the required mechanical properties and other requirements herein, that have similar or better weld ability, and that have a documented history of successful application may be submitted for approval by the Engineer. The steel shall be fully killed and made to fine grain practice.

ELEMENT (Max. or range)	BASE GRADE	C	Si	Mn	P	S	Ni	Cr	Mo
Structural Casting Grade 345	A148M, Gr. 550-345	0.20	0.60	1.50	0.02	.010	1.2	0.50	0.25
Structural Casting Grade 415	A148M, Gr. 620-415	0.28	0.80	1.00	0.02	.010	1.40 - 2.00	0.55-0.90	0.20-0.40
Structural Casting Grade 550	A148M, Gr. 725-585	0.24	0.50	0.55-0.75	0.02	.010	2.50 - 3.50	1.35-1.85	0.30-0.60

ELEMENT (Max. or range)	BASE GRADE	Al	Cu	V	Cb	Ti	CE
Structural Casting Grade 345	A148M, Gr. 550-345	.010 – .060	0.30	0.03	0.03	0.05	0.51
Structural Casting Grade 415	A148M, Gr. 620-415	.010-.030	0.50*	0.03*	0.03	0.05	0.90
Structural Casting Grade 550	A148M, Gr. 725-585	.010-.030	0.20*	0.03*	0.03	0.05	-

Notes: * means not intentionally added.

CE = C + (Mn+Si)/6 + (Cr + Mo + V)/5 + (Cu + Ni)/15

Each casting shall be given a double normalized or a normalized plus quench and temper heat treatment at temperatures and times specified in the manufacturing procedure except the final tempering temperature shall not be less than 565 C. Specimens for mechanical testing shall be taken from a representative casting, a prolongation to the casting or a keel block. The test specimen block shall have a section size equivalent to 1/3T of that shown on the plans, be poured from the same ladle and heat treated along with the castings that it represents. The test specimens shall meet the requirements in the table below. In addition, a separate keel block with the equivalent maximum section size shown on the plans shall be poured from the same heat, heat treated along with the casting and machined to provide two tensile test specimens. The tensile yield and ultimate strengths of these specimens shall not be less than 90% of the minimum strengths specified in the table below.

	STRUCTURAL CASTING GRADE 345	STRUCTURAL CASTING GRADE 415	STRUCTURAL CASTING GRADE 550
Tensile Strength:	550 MPa – 690 MPa	620 MPa – 795 MPa	680 MPa – 840 MPa
Yield Strength:	345 MPa, Minimum	415 MPa, Minimum	550 MPa, Minimum
Elongation:	22%, Minimum	20%, Minimum	18%, Minimum
Reduction of Area:	35%, Minimum	35%, Minimum	30%, Minimum
Charpy V-Notch:	42 J, Minimum at 0° C	42 J, Minimum at 0° C	90 J, Minimum at 0° C

Each casting shall be visually examined 100% on all surfaces and shall be free of adhering sand, scale, cracks, shrinkage, unfused chills and hot tears and meet the Manufacturing Standardization Society of the Valve and Fittings Industry Inc. Publications (MSS) specification MSS-SP-55, "Quality Standard for Steel Castings for Valves, Flanges and Fittings and Other Piping Components - Visual Method". Machined surfaces shall be free of voids or other discontinuities that exceed the following: A maximum of one discontinuity within a radius of 150 mm that has a diameter not exceeding 3 mm within the saddle troughs or 5 mm elsewhere, a maximum depth of one half of the diameter, and a rounded shape with no sharp corners. Voids within the saddle troughs shall be filled during metallizing.

Each casting shall be examined 100% on all surfaces by visible contrast, wet magnetic particle method to ASTM Designation: E709 on the final, as-finished surface. The prod method shall not be used on Grades 415 or 550 and shall be controlled to eliminate arcing. Linear indications, defined as having a ratio of maximum to minimum dimensions greater than 3, tears and cracks will not be permitted.

Each casting shall also be volumetrically examined 100% by ultrasonic (UT) methods in accordance with a written procedure submitted with the manufacturing procedure. The procedure shall define calibrations, equipment and materials and shall include part-specific shooting sketches that demonstrate complete coverage of the full volume from two perpendicular directions. Coverage shall be compatible with locations identified as possible locations for defects based on the finite element heat flow analysis and the foundry practice. Ultrasonic procedures shall be based on ASTM Designation: A 609, "Standard Specification for Longitudinal Beam Ultrasonic Inspection of Carbon and Low-Alloy Steel Castings," using Procedure A, except supplementary angle beam examination to Supplementary Requirement S1 shall be performed on castings to ensure coverage from two perpendicular directions and on areas of castings where a back reflection cannot be maintained during straight beam examination, or where the angle between the front and back surfaces of the castings exceeds 15 degrees. The Distance Amplitude Curve (DAC) method shall be used for both straight and angle beam examinations. The DAC shall be constructed using a 3.0 mm diameter reference reflector hole for areas within 30 mm of the final surface unless noted otherwise on the plans, and areas designated as Level 1 on the plans, and a hole diameter as specified in ASTM Designation: A 609M shall be used elsewhere. At each facility producing castings, ultrasonic test calibration blocks shall be poured from the first casting heat produced for this contract. The calibration blocks shall be made available to the Engineer for use in QA testing of the castings and to any subcontractors that perform ultrasonic testing on the castings. All calibration details shall be defined in the procedure.

The ultrasonic examination acceptance criteria shall be as follows: Within 30 mm of any final surface, unless otherwise noted on the plans, and at locations designated as Level 1 on the plans, indications that provide a response equal to or greater than the DAC and that are planar or that exceed the area specified in ASTM Designation: A 609, Table 2 for ultrasonic testing quality Level 1 will not be permitted. At all other locations, indications that provide a response equal to or greater than the DAC and that are planar or that exceed the area specified in ASTM Designation: A 609, Table 2 for ultrasonic testing quality Level 3 will not be permitted. The method for determining whether a reflector is planar shall be defined in the written procedure and shall be based on the high directionality of amplitude response for planar reflectors or other established technique.

Each casting shall be stenciled with its heat number and serial number.

Before casting, the Contractor shall produce 1/10 scale model of the tower saddle in wood or other material approved by the Engineer. The model shall show all details of the saddle including the location of weld, cast and plate materials and cast component parting lines. The model and manufacturing procedure shall be approved by the Engineer before the start of foundry production.

All areas of steel castings that will be in contact with other elements by welding, bolting or direct contact pressure shall be machined.

Unless noted otherwise on the plans, the tolerance for linear dimensions of unmachined sections shall have a plus and minus tolerance (i.e., one half of the total tolerance range) in accordance with the following table:

Tolerance For Linear Dimensions (mm) Unaffected By Machined Surfaces

LINEAR DIMENSION, L	L < 60	60 ≤ L < 120	120 ≤ L < 250	250 ≤ L < 400	400 ≤ L < 630	630 ≤ L < 1000	1000 ≤ L< 1600	1600 ≤ L < 2500	2500 ≤ L < 4000	4000 ≤ L
TOLERANCE	4.5	5.5	7.0	9.0	11.0	13.0	16.0	19.0	31.0	47.0

Unless noted otherwise on the plans, the thickness tolerance of unmachined ribs shall have a minus tolerance of 3 mm and a plus tolerance in accordance with the following table:

Plus Tolerance For Thickness Of Ribs (mm) Where Both Faces Are Not Machined

THICKNESS RANGE	t < 18	18 ≤ t < 30	30 ≤ t < 50	50 ≤ t < 80	80 ≤ t < 120	120 ≤ t < 180	180 ≤ t < 250	250 ≤ t < 315	315 ≤ t < 400	400 ≤ t
PLUS TOLERANCE	6.0	9.0	10.0	11.0	12.0	13.0	15.0	19.0	27.0	35.0

No coating or oil preservative shall be applied to a casting until that casting has been inspected and approved by the Engineer.

Minor defects may be removed by grinding or chipping without welding repair, in accordance with the following requirements:

A. The removal of metal does not affect the strength, integrity or functionality of the casting, as determined by the Engineer.
B. The remaining wall thickness is equal to or greater than the required minimum wall thickness.
C. The surrounding metal is ground to a smooth contour with the elimination of apparent stress raisers.
D. Specified tolerances on machined surfaces are satisfied.

Weld repairs may be permitted if qualified welding procedures are used that demonstrate Charpy V-Notch toughness of 34J at –30 C in the weld metal and 34J for Structural Casting Grades 345 and 415, or 60J for Structural Casting Grade 550, at 0 C in the heat-affected zone in the final delivery condition. Weld procedure tests shall be qualified on 50 mm thick plates poured from the same heat as the final casting. Weld repairs shall be given a post weld stress relief heat treatment after all welding is complete. All proposed repair or upgrading welding procedure specifications (WPSs) shall conform to the requirements of ASME Boiler and Pressure Vessel Code, Section IX, as modified herein. Additional essential variables required for WPSs other than SMAW shall include welding travel speed (limited to ±10%), heat input (limited to +10%, -30%), and, for FCAW, the brand name of the electrode. Weld procedures with all supporting procedure qualification records (PQRs) shall be submitted in writing to the Engineer for each welding location, and shall include a description of the defect or other need for welding, the size and the shape of the excavation, the welding procedure specification, preheat and post weld heat treatment. If a second repair to base metal or heat affected zone is required at the same location, the Contractor shall include a metallurgical evaluation for the cause of the rejection in the submittal package to the Engineer for review and approval.

No welding or heat treatment will be permitted except with the specific written approval of the Engineer. In addition, the Contractor shall give the Engineer at least 12 hours notice prior to performing the work.

The exterior surfaces of the castings, after acceptance, shall be coated as specified in "Clean and Paint Structural Steel" and "Metallized Steel Surfaces" of these special provisions. The castings shall be carefully masked to avoid coating any high strength fastener contact surface, interior or other machine finished surface.

At the time of assembly, the contact surfaces of the castings shall meet the machine finish requirements shown on the plans.

FABRICATION

Quality of Workmanship

All bridge elements shall be cut, trimmed, fabricated and erected to be true at the average bridge temperature, as shown on the plans. All corners of members shall be rounded to a minimum radius of 2 mm, unless otherwise shown on the plans.

The Engineer may inspect fabrications for dimensional accuracy, fabrication practices, welding requirements and compliance with these special provisions.

Shop Size

The shop or yard shall be of sufficient size and shall have adequate facilities to permit checking and controlling of the alignment of the box girder and tower lifts before they are shipped to the site. Shop or yard size shall be sufficient to join any three contiguous segments or any lift plus an adjacent segment, whichever is larger.

Fabrication/Erection Procedure and Mock-Ups

The Contractor shall submit to the Engineer for approval in accordance with the requirements in “Working Drawings” of these special provisions, written, detailed procedures for the fabrication and erection of the complex assemblies listed below. Procedures shall include the assembly and welding sequence, and bolt tightening procedure and shall be of sufficient detail to demonstrate the proposed fabrication procedure and verify the inspectability of welds.

Attention is directed to “Bolted Connections,” of this section regarding bolt tensioning requirements.

Fabrication and erection procedures are required for all locations where a mock-up is required and for the following additional locations:

A. Tower Anchorage
B. Tower Shaft Segment, including Shell Plating Sequence
C. Box Girder Segment

D. Crossbeam to Box Girder Connection
E. West Deviation Saddle Assembly
F. Box Girder Connection PT Strand End Block to Pier W2 Cap Beam
G. East Cable Anchorage Overall Assembly
H. East Saddle Assembly
I. Tower Diaphragm Types 1A and 1B
J. Hinge A Assembly
K. Tower Strut Assembly including connection to Tower Diaphragm
L. Tower saddle grillage
M. West Jacking Frame box
N. West Jacking Saddle
O. Box girder reinforcement at East Saddle and Pier E2 bearing and Shear Key
P. Pier E2 Bearing and Shear Key
Q. Box lift erection connection

The Contractor shall prepare steel mock-ups, unless otherwise noted, of the following details to demonstrate the proposed fabrication procedure and verify the inspectability of each weld:

A. Tower Saddle (steel mock-up not required)
B. Tower Diaphragm Type 3B
C. Tower lift erection splice – bolted or welded
D. Hinge K Assembly (steel mock-up not required)
E. Deck plate section – (For welding requirements of closed ribs to deck plate, see "Welding of Closed Ribs to Box Shell Plates" below.)"
F. Tower section

Each mock-up shall comprise a complete fabrication of the specified detail as shown on the plans, but with member lengths that need not extend beyond the joint more than 0.5m.

For each mock-up, the Contractor shall prepare a written fabrication and welding sequence and a preliminary mock-up made of wood, plastic, dense Styrofoam or other material approved by the Engineer. The preliminary mock-up shall be sufficiently large to demonstrate the assembly sequence, but need not exceed one-half scale. These shall be submitted for review by the Engineer, and approval shall be given before the full-scale mock-up is fabricated in steel. The Engineer shall witness all fit-up and welding for each steel mock-up.

The completed steel mock-up shall be examined visually and by UT or RT and by Magnetic Particle (MT) using the nondestructive examination procedures that are proposed for production. Mock-up assemblies shall then be sectioned as directed by the Engineer to produce three macroetch samples per weld that shall be evaluated per AWS D1.5. Approval of the fabrication and erection procedure and the nondestructive examination procedures shall be contingent on satisfactory results from the mock-up examination and destructive tests.

Mock-ups shall not be part of the permanent structure and shall become the property of the Contractor. Mock-ups shall be removed from the work site and shall be disposed of in conformance with the provisions in Section 7-1.13, "Disposal of Material Outside the Highway Right of Way," of the Standard Specifications.

Hinge K Pipe Beam

The Contractor shall fabricate pipe beams in accordance with the approved fabrication procedure conforming to the requirements of these special provisions. Welding of the pipe beam longitudinal and circumferential groove welds and stainless steel cladding shall be made using the SAW process unless otherwise approved by the Engineer.

Pipe beams shall be formed in sections that are welded with one or two longitudinal seams. Forming shall be performed at ambient temperature unless approved and qualified at elevated temperature, which shall not exceed 590˚ C or the maximum temperature recommended by the steel manufacturer, whichever is less. Metal forming at temperatures between 150˚C and 425˚C will not be permitted. Prior to machining, the formed pipe beam shall have a smooth surface with local roundness variations less than 5 mm, as measured against a template with the theoretical curvature and length of 20 degrees, and out-of-roundness (maximum diameter minus minimum diameter) less than 8 mm.

Welding and welding procedure qualification for Pipe Beam Grade 485 and Pipe Beam Grade 690 shall conform to "Welding of HPS485W Steels" and "Welding of Grade 690 Steels" sections below, respectively, in addition to the following. Welding procedures for the longitudinal and circumferential welds shall be qualified by welding test pieces with the maximum thickness to be welded in production in the as-formed condition representing the maximum strain. Testing shall include all tests required by AWS D1.5 Section 5.7.1 for Test Plate A and the additional tests described herein. Charpy V-Notch test specimens shall be removed from the weld metal and coarse grain heat affected zone for longitudinal and circumferential welds. Heat affected zone toughness test specimens shall be removed from the inner and outer surfaces of the formed member. Charpy V-Notch test results for both weld metal and heat affected zone shall meet the requirements specified under “Materials” above.

The AISI 316L stainless steel overlay shall be welded over the full specified pipe beam thickness using a procedure qualified for the Pipe Beam Grade 690 in accordance with AWS D1.6. Chemical analysis shall be performed on the qualification overlay 5 mm above the substrate and shall meet the chemical limits for grade 316L. After overlay welding, the stainless steel surfaces shall be machined to a root mean square surface finish of 0.8 µm, with no gouges or indentations, and an out-of-roundness on the machined surface (max. OD – min. OD) not exceeding 1 mm.

The cylinder defined by the machined stainless steel surface shall be straight and concentric to the pipe beam axis within 1 mm.

The extent of nondestructive testing shall be as defined under Inspection and Testing below. Acceptance shall be based on the criteria for tension welds in primary members. Visual and nondestructive examination of welds shall be accepted before cladding is started. Finish machined stainless steel surfaces, plus 100 mm of the pipe beam on either side of the stainless steel surfaces, shall be examined 100% by liquid penetrant testing (PT) in accordance with ASTM Designation: E165, and the standards of acceptance shall be in accordance with AWS D1.5, Section 6.26.

Spare Pipe Beam Fuses

The Contractor shall fabricate spare pipe beam fuses in accordance with the details shown on the plans and the requirements of this section. Spare pipe beam fuses shall conform to the requirements of this section, including the requirements for cleaning and painting in the section “Clean and Paint Structural Steel,” of these special provisions.

The Contractor shall deliver the spare pipe beam fuses to the Engineer at a location to be determined by the Engineer. Said location will be within 25 km of the San Francisco-Oakland Bay Bridge Toll Plaza. Spare pipe beam fuses shall be delivered to the Engineer within six months prior to completion of the work. The Contractor shall notify the Engineer at least two months prior to delivery of spare pipe beam fuses.

Spare pipe beam fuses shall be packaged for the protection of the steel against physical damage and corrosion during shipping and storage. The shipping package shall be clearly marked with a statement that the package contains spare pipe beam fuses for the San Francisco-Oakland Bay Bridge and show the hinge location, the serial number, grade of steel, and the date packaged.

Spare Tower Struts

The Contractor shall fabricate spare tower struts in accordance with the details shown on the plans and the requirements of this section. Spare tower struts shall conform to the requirements of this section, including the requirements for cleaning and painting in the section “Clean and Paint Structural Steel,” of these special provisions.

The Contractor shall deliver the spare tower struts to the Engineer at a location to be determined by the Engineer. Said location will be within 25 km of the San Francisco-Oakland Bay Bridge Toll Plaza. Spare tower struts shall be delivered to the Engineer within six months prior to completion of the work. The Contractor shall notify the Engineer at least two months prior to delivery of spare tower struts.

Spare tower struts shall be packaged for the protection of the steel against physical damage and corrosion during shipping and storage. Spare tower struts shall be packaged individually and include their associated attachment plates, angles, and bolts. The shipping package shall be clearly marked with a statement that the package contains spare tower struts for the San Francisco-Oakland Bay Bridge, the strut type, the serial number, and the date packaged.

Bikepath at Pier W2

A portion of the bikepath at Pier W2 will be furnished by the Contractor and installed by others, as shown on the plans. This portion of bikepath shall conform to the requirements of this section, including the requirements for cleaning and painting in section "Clean and Paint Structural Steel," of these special provisions.

The Contractor shall deliver this portion of bike path to the Engineer at a location to be determined by the Engineer. Said location will be within 25 km of the San Francisco-Oakland Bay Bridge Toll Plaza. The Contractor shall notify the Engineer at least two months prior to delivery of this portion of the bike path.

This portion of bikepath shall be protected against physical damage and corrosion during shipping and storage.

Mechanical Cutting

Mechanical shearing of material of thickness greater than 8 mm is prohibited. Mechanically sheared edges shall be ground smooth. All cracks emanating from these edges shall be removed.

Flame, Plasma And Arc Cutting

All cut edges in SPCMs and steel grades greater than grade 345 shall be ground to remove dross, slag and hardened material. The treatment of cut edges for other grades shall conform to the requirements of AWS D1.5.

Bent Plate

Cold-bent steel plates except closed ribs for the box girder shall conform to the following:

A. The axis of bending shall be perpendicular to the direction of plate rolling. The entire length of bend shall be formed simultaneously.
B. The radius of bend shall be as shown on the plans.
C. Before bending, the plate corners that are perpendicular to the axis of the bend shall be rounded to a radius of 2 mm.

Rib Plates

Cold-bent steel closed rib plates for the orthotropic deck shall conform to the following:

A. The axis of bending shall be parallel to the direction of plate rolling. The entire length of rib shall be formed simultaneously. Progressive forming methods such as roll forming will not be permitted.
B. The radius of bend of closed rib plates, measured to the concave face of the metal shall be as shown on the plans.
C. Before bending, the corners of the plate perpendicular to the axis of the bend shall be rounded to a radius of 2 mm. The Contractor's proposed method shall be capable of bending the plates without introducing cracks at the edges or along the bent section. The Contractor shall demonstrate to the Engineer that the proposed method results in satisfactory bends. The Engineer will determine if the proposed method is acceptable. Acceptance of the Contractor's proposed bending method will be based on nondestructive tests on ten ribs and macroetches on three of the ribs previously tested nondestructively. Ribs shall be a minimum of 10m long. The Contractor shall perform the following tests:

    A. Visual examination of the bends using a 5x magnifying lens.
    B. Magnetic Particle testing of all termination edges at rib ends and 15% of the bent parts of the ribs at locations selected by the Engineer. No cracks will be permitted.
    C. Destructive testing of up to three ribs, with 5 macroetches per rib, at locations selected by the Engineer.

    The Contractor shall bend and trim ribs and shell plating to ensure that the geometric tolerances shown on the plans are met.

The Contractor's proposed method shall be capable of bending the plates without introducing cracks at the edges or along the bent section. The Contractor shall demonstrate to the Engineer that the proposed method results in satisfactory bends. The Engineer will determine if the proposed method is acceptable. Acceptance of the Contractor's proposed bending method will be based on nondestructive tests on ten ribs and destructive tests on three of the ribs previously tested nondestructively. Ribs shall be a minimum of 10 m long. The Contractor shall perform the following tests:

A. Visual examination of the bends using a 5x magnifying lens.
B. Magnetic Particle testing of all termination edges at rib ends and 15% of the bent parts of the ribs at locations selected by the Engineer. No cracks will be permitted.
C. Destructive testing of up to three ribs, with 5 samples per rib, at locations selected by the Engineer.

The Contractor shall bend and trim ribs and shell plating to ensure that the geometric tolerances shown on the plans are met.

Match-Marking

Match markings shall be made with low stress die stamps or other method that will not notch the steel.

Bolted Connections

Bolted connections in structural steel joints, unless otherwise shown on the plans or specified in the special provisions, shall be made with high-strength steel fastener assemblies. Fastener assemblies shall consist of a high-strength steel bolt, nut and hardened washer.

The provisions of Section 8-1.01 "SUBSTITUTION OF NON-METRIC MATERIALS AND PRODUCTS," will not be permitted for high-strength fastener assemblies.

Tightening of bolted connections shall be completed in a set pattern with a minimum of two cycles: snug tight and full tension.

The method for determining bolt tension shall include calibration using a calibrated bolt tension calibrator. The tightening pattern and the calibration and tightening procedure shall be included in the fabrication/erection procedure and submitted to the Engineer for approval.

For the tower shaft bolted splice, all plies of the bolted connections for all faces shall be brought into alignment and full contact before tightening commences. The tower lift ends shall be milled to bear and shall be in full contact before bolting together. The Contractor shall prepare a work plan that shall describe the procedure for meeting these requirements and that shall be approved by the Engineer before use. The work plan shall be demonstrated on the mock-up required above. The mating segments of each lift shall be mated at the fabrication site, and the required fit demonstrated, before moving each lift to the final assembly site.

Bolted connections shall conform to the requirements in the Research Council on Structural Connections, "Specification for Structural Joints Using ASTM A325 or A490 Bolts," 2000 (RCSC Specification), with the following revisions:

A. Reference to A325 bolts shall mean A325M bolts.
B. Reference to A490 bolts shall mean A490M bolts.
C. Reference to A563 nuts shall mean A563M nuts.
D. Reference to F436 washers shall mean F436M washers.
E. Reference to F959 direct tension indicators shall mean F959M direct tension indicators.
F. Reference to F1852 twist-off type tension control bolts shall not apply.
G. Reference to ANSI B18.2.6 (for bolt dimensions) is replaced with B.18.2.3.7M.
H. Reference to ANSI B18.2.6 (for nut dimensions) is replaced with B.18.2.4.6M.

I. Replace Table 2.1 of the RCSC Specification with Table 8.1 of the AISC "Manual of Steel Construction, Load & Resistance Factor Design, Metric Conversion of the Second Edition" (AISC Specification).

J. Replace Table C-2.1, Figure C-2.2, and Table C-2.2 of the RCSC Specification with Table 8.2 of the AISC Specification.

K. Replace Table 3.1 of the RCSC Specification with Table J3.3 of the AISC Specification.

L. Section 6.2.3. of the RCSC is deleted.

M. Table 6.1 of the RCSC Specification is replaced with the following:

Table 6.1. Washer Requirements for Bolted Joints with Oversized and Slotted Holes in the Outer Ply

<table>
<tr><td rowspan="2">ASTM Designation</td><td rowspan="2">Nominal Bolt Diameter db, mm</td><td colspan="3">Hole Type in Outer Ply</td></tr>
<tr><td>Oversized</td><td>Short-Slotted</td><td>Long-Slotted</td></tr>
<tr><td>A325</td><td>12-36</td><td colspan="2" rowspan="2">ASTM F436M</td><td>8 mm thick plate washer or continuous bar[a,b]</td></tr>
<tr><td rowspan="2">A490</td><td>≤ 25</td><td></td></tr>
<tr><td>>25</td><td colspan="2">ASTM F436M with 8 mm thickness[a]</td><td>8 mm thick hardened plate washer or hardened continuous bar[a]</td></tr>
<tr><td colspan="5">[a] Multiple washers with a combined thickness of 8 mm or larger do not satisfy this requirement.
[b] The plate washer or bar shall be of structural-grade steel material, but need not be hardened.</td></tr>
</table>

N. Replace Table 8.1 of the RCSC Specification with the following:

Minimum Bolt Tension, N*

Bolt Size, mm	A325M Bolts	A490M Bolts
M16	91 000	114 000
M20	142 000	179 000
M22	176 000	221 000
M24	205 000	257 000
M27	267 000	334 000
M30	326 000	408 000
M36	475 000	595 000
*Equal to 0.70 of minimum tensile strength of bolts, rounded off to nearest kN and converted to N, as specified in ASTM specifications for A325M and A490M bolts with UNC threads.		

O. Table 8.2 of the RCSC Specification is replaced with the following:

Table 8.2. Nut Rotation from Snug-Tight Condition for Turn-of-Nut Pretensioning [a,b]

Bolt Length[c]	Disposition of Outer Face of Bolted Parts		
	Both faces normal to bolt axis	One face normal to bolt axis, other sloped not more than 1:20[d]	Both faces sloped not more than 1:20 from normal to bolt axis[d]
Not more than $4d_b$	1/2 turn	1/2 turn	2/3 turn
More than $4d_b$ but not more than $8d_b$	1/2 turn	2/3 turn	5/6 turn
More than $8d_b$ but not more than $12d_b$	2/3 turn	5/6 turn	1 turn

[a] Nut rotation is relative to bolt regardless of the element (nut or bolt) being turned. For required nut rotations of ½ turn, the tolerance is plus 30 degrees; for required nut rotations of 2/3 turn and more, the tolerance is plus 45 degrees.
[b] Applicable only to joints in which all material within the grip is steel.
[c] When the bolt length exceeds 12dh, the required nut rotation shall be determined by actual testing in a suitable tension calibrator that simulates the conditions of solidly fitting steel.
[d] Beveled washer not used.

P. Sections 8.2.2, 8.2.3, 9.2.2, and 9.2.3 of the RCSC Specification are deleted.

Where the DTI method is used, the DTI shall be collapsed to 0.075mm (3 mils), and the gap in the DTI shall be caulked after acceptance by the Engineer. The method of bolt tightening shall be as specified below:

LOCATION	BOLT TYPE	COATING	TIGHTENING METHOD
Tower	A325	Mechanical galvanizing	Turn-of-Nut or Direct Tension Indicator (DTI) collapsed to 3mils (0.075mm) on inside of Tower
	A490	Organic zinc coating	Turn-of-Nut or DTI collapsed to 3mils (0.075mm) on inside of Tower
Box Girder	A325	Mechanical galvanizing	Turn-of-Nut, TC or DTI collapsed to 3mils (0.075mm) on inside of box
Tower Skirt	A307	Hot Dip Galvanized	Snug-Tight
Saddle Housing	A307	Hot Dip Galvanized	Snug-Tight plus 1 turn

The bolt orientation shown on the plans may be reversed to facilitate installation as approved by the Engineer.

High-strength fastener assemblies, and other bolts attached to structural steel with nuts and washers shall be zinc-coated as shown. When direct tension indicators are used in these assemblies, the direct tension indicator and all components of the fastener assembly shall be zinc-coated by the mechanical deposition process. Stripping and re-dipping of galvanized high strength fasteners is prohibited.

At least 60 working days prior to beginning turn-of-nut bolting operations, the Contractor shall perform the following tests to verify turn-of-nut installation procedures:

A. Minimum tension shall be verified using the "Pre-Installation Verification Turn-of-the-Nut Method," of the "Structural Bolting Handbook," published by the Steel Structures Technology Center, Incorporated, except that the required rotation shall be as given in Table 8.2. of this section and the required tension shall be as shown in the following table:

Pre-Installation Verification
Required Tension, N*

Bolt Size, mm	A325M Bolts	A490M Bolts
M16	96 000	120 000
M20	149 000	188 000
M22	185 000	232 000
M24	215 000	270 000
M27	280 000	351 000
M30	342 000	428 000
M36	499 000	625 000
*The above values are 5% higher than the required pretension values used for design, actual installation and inspection, rounded to the nearest kN.		

B. Rotational-capacity tests in accordance with the requirements in Section 11.5.6.4.2 "Rotational-Capacity Tests," of the AASHTO LRFD Bridge Construction Specifications, except that Table 11.5.6.4.1-2 "Nut Rotation from the Snug Condition," is replaced by Table 8.2. of this section.

Test results shall confirm both the minimum bolt tension and the rotational capacity of the bolts. If either test fails, the Contractor shall modify the nut rotation in Table 8.2. of this section until the requirements of both tests are satisfied. No adjustment in compensation will be allowed for modifications to the nut rotations as necessary to satisfy test requirements. Revisions to Table 8.2. shall be approved by the Engineer prior to bolting operations.

The Engineer will randomly sample and perform quality assurance testing of high strength fasteners. Samples will be obtained at locations chosen by the Engineer. The Contractor shall provide the number of bolts specified below to the Engineer for quality assurance testing:

Bolt Sampling Size

Lot Size (No. of Bolts)	Sample Size (No. of Bolts)
2 to 15	3
16 to 25	4
26 to 50	5
51 to 90	7
91 to 150	8
151 to 280	9
281 to 10,000	12
10,001 to 500,000	16
500,001 and over	20

Steel fasteners, designated on the plans as A 354, Grade BC, and A 354, Grade BD, shall conform to the requirements of ASTM Designation: A 354. Steel fastener components for steel fasteners designated as A 354 shall include a bolt, nut and hardened washer. Nuts for steel fasteners designated as A 354 shall conform to Section 55-2.01, "Description," of the Standard Specifications.

Steel fasteners designated on the plans as A 354, Grade BD shall be dry blast cleaned in accordance with the provisions of Surface Preparation Specification No. 10, "Near White Blast Cleaning," of the "SSPC: The Society for Protective Coatings.

Steel fasteners designated on the plans as A 354, Grade BC, and A 354, Grade BD, shall be galvanized in accordance with the requirements in Section 75-1.05, "Galvanizing," of the Standard Specifications and shall conform to the requirements in ASTM Designation: A123 for bolts and ASTM Designation: A153 for nuts and hardware. Steel fastener assemblies designated as A354, Grade BD, shall be galvanized within 4 hours of being dry blast cleaned.

The Contractor shall submit certified test reports showing that the A 354, Grade BD fasteners conform to the provisions in ASTM Designation: A 143.

Steel fasteners, designated on the plans as A 354, Grade BC, and A 354, Grade BD, shall conform to the requirements of ASTM Designation: A 354. Steel fastener components for steel fasteners designated as A 354 shall include a bolt, nut and hardened washer. Nuts for steel fasteners designated as A 354 shall conform to Section 55-2.01, "Description," of the Standard Specifications. Nuts shall be zinc coated and be furnished with a dry lubricant conforming to Supplementary Requirement S1 and S2 in ASTM Designation: A 563.

Steel fasteners designated on the plans as A 354, Grade BD shall be tensioned not less than the value shown on the plans. Prior to installation, the Contractor shall submit to the Engineer for approval the methods and equipment to be used to tension steel fasteners designated as A354, Grade BD in accordance with Section 55-1.02, "Drawings," of the Standard Specifications. Working drawings shall include methods and equipment to be used to evaluate: 1) the presence of a lubricant, 2) the efficiency of the lubricant, and 3) the compatibility of the high strength steel bolt, nut and hardened washer.

Except where sub-punching is permitted, bolt holes shall be drilled or reamed, unless otherwise shown on the plans.

Punching

The first paragraph of Section 55-3.14A(1) “Punching,” of the Standard Specifications shall not apply.

Punching or sub-punching of Grade 250 structural steel where the material is thicker than 16 mm will not be permitted. Punching or sub-punching of high-strength structural steel where the material is thicker than 12 mm will not be permitted.

Prestressing High-Strength Bolts

High-strength A354 bolts shall be tensioned by means of hydraulic jacks so that the force in the bolts shall not be less than the value shown on the plans.

The maximum temporary tensile stress (jacking stress) in high-strength bolts shall not exceed 75 percent of the specified minimum ultimate tensile strength of the material. Prestressing forces in high-strength bolts shall consider all losses, including creep of steel, losses due to sequence of stressing, and other losses specific to the method or system of prestressing used by the Contractor.

Hydraulic jacks used for prestressing high-strength bolts shall be calibrated in accordance with the requirements in Section 50-1.08, "Prestressing," of the Standard Specifications.

Final prestressing high strength A354 bolts at the tower anchorage shall be performed after the full dead load is transferred to the cable system.

ASSEMBLY

The method of erection of the suspended structure and tower shall be determined by the Contractor to ensure control of box girder and tower deflections due to wind induced oscillations.

The Contractor shall carry out the necessary structural analyses for the erection procedure to demonstrate the adequacy of the procedure. Details of these analyses and of any supplementary damping or other measures shall be submitted to the Engineer for review and approval.

Wind pressure effects during erection shall be calculated using a gust wind appropriate to a return period of not less than 25 years and shall allow for variation of speed with height per ANSI ASCE 7-95. The 25-year wind corresponds to a 77 mph one-hour average wind speed (and a corresponding 3-second gust wind speed of 100 mph) at deck elevation of 50 meters, as well as a critical flutter wind speed threshold of 112 mph based on a 1000-year return period. The Contractor shall provide temporary connections between adjacent lift sections in order to ensure sufficient torsional stiffness of the suspended structure. The Contractor shall also provide the proper support of the suspended structure during all stages of erection. The Contractor shall similarly ensure control of tower deflections due to wind-induced oscillations at all stages of erection and shall provide holdback stays or other damping devices as necessary. All such temporary measures shall be approved by the Engineer.

The erection procedure shall be such that the maximum stresses in any part of the permanent structure do not cause any permanent deformation or damage. Appropriate values of loads and safety factors for erection loading conditions shall be submitted by the Contractor to the Engineer for review and approval.

The details of any fastenings which the Contractor may require in any part of the permanent works for erection, and the procedure for their removal, shall be submitted to the Engineer for approval.

Tower Lift Sections

Tower lifts shall be in lengths as indicated on the plans. Exterior plates of the tower shafts shall be fabricated with direction of rolling aligned along the vertical direction of the tower. Within each lift, the number of transverse splices of the plates shall be minimized. Tower skin plate vertical seams shall be located a minimum of 100 mm away from longitudinal stiffeners unless otherwise shown on the plans. Each tower shaft segment shall be fabricated horizontally in a fixture so that all welds in the longitudinal direction of the tower shaft can be made in the horizontal or flat position. Welds between tower shaft segments shall be made in the horizontal or flat position. A full size template shall be used to control the tolerances between the tower shafts. A template is defined as a plate of a shaft that is used to produce identical cross-sections for the tower shafts.

The ends of each lift shall meet the dimensional requirements given under "Shop Welding," subsection "Design Details" of these special provisions. Each end shall be in a horizontal plane. When standing on its lower end, the top corners of each lift shall remain within specified limits in both horizontal directions. To limit cumulative displacements, ends of the higher lift shall be milled to compensate for the actual elevation of the lower lift, if the cumulative displacements are not within specified limits.

The fillet reinforcement required by Note 6 of Figures 2.4 and 2.5 of AWS D1.5 will not be required for PJP welds in the tower.

The tower interior corner splice plates shall be beveled 6 mm to clear weld beads on inside joint of tower corner skin plates subject to approval of the Engineer.

The ends of adjacent lifts shall be abutted together in the shop to ensure proper fit.

Shear stresses shall not be induced in the tower struts at any time during the tower erection. At the option of the Contractor, cross bracing and shear links may be used to obtain the required tolerances between shafts provided the axial loads in the cross bracing or shear links, after complete erection of tower, do not exceed 1 MN per member and the locked-in stresses along the entire length of each shaft does not exceed 5% of yield stress. The Contractor shall estimate the force and stresses in these members, including the locked-in stresses in each shaft after complete erection of tower, based on the approved erection plan and submit the calculations to the Engineer for review and approval. Bolt holes for the shear link connection plates may be field drilled subject to review and approval by the Engineer. The pin holes for the cross bracing may be bored in the shop to match field measurements subject to review and approval by the Engineer. The layout of the bolt holes shall be submitted to the Engineer for approval.

Box Girder

Box girder sections shall be fabricated in segments as shown on the plans. Box girder shell plates shall be fabricated with the direction of rolling aligned with the longitudinal axis of the bridge. Splices within segments shall be welded unless otherwise noted on the plans. Segments and lifts shall be dimensionally checked for matching, alignment, and camber, and shall not be shipped to the job site without prior approval of the Engineer.

Before shipping, segments and lifts shall be straight and square in accordance with the dimensions and tolerances shown on the plans and these special provisions, except as required by camber. Segments shall be measured in the shop for compliance with geometry requirements. As a minimum, the preassembly procedure shall consist of assembling three contiguous segments accurately adjusted for line and camber. Successive assemblies shall consist of at least one section of the previous assembly plus two or more sections added at the advancing end. This requirement shall also apply to segments shipped from the fabrication site to an assembly site where the segments will be joined into lifts. The support conditions shall be the same as those in the final installed condition; alternative support conditions may be proposed with details submitted under the erection plan and supported by calculations showing the effect of the support conditions on dimensional tolerances and segment-to-segment fit-up tolerances.

The Contractor shall develop the camber diagram of the box girder consistent with his proposed erection procedure. Shimming, forcing or prying will not be permitted.

Crossbeams

Crossbeams shall be connected to the suspended structure prior to transferring dead load to the suspension system.

The Contractor shall develop the camber diagram of the crossbeam consistent with his proposed erection procedure. Shimming, forcing or prying will not be permitted.

SURFACE PREPARATION

For all bolted connections, the contact surfaces and inside surfaces of bolt holes shall be cleaned and coated before assembly in conformance with the provisions for cleaning and painting structural steel of these special provisions.

WELDING OF STEEL STRUCTURES

Table 2.2 of ANSI/ AASHTO/AWS D1.5 is superseded by the following table:

Base Metal Thickness of the Thicker Part Joined, mm	Minimum Effective Partial Joint Penetration Groove Weld Size, * mm
Over 6 to 19 inclusive	6
Over 19 to 38 inclusive	8
Over 38 to 57 inclusive	10
Over 57 to 150 inclusive	13
Over 150	16

* Except the weld size need not exceed the thickness of the thinner part

Dimensional details and workmanship for welded joints in tubular and pipe connections shall conform to the provisions in Part A, "Common Requirements of Nontubular and Tubular Connections," and Part D, "Specific Requirements for Tubular Connections," in Section 2 of AWS D1.1.

Backing for welds that are subject to computed stress which are left in place in the completed structure as shown on the plans or approved by the Engineer shall be a single length. Single lengths of backing shall be obtained by using a continuous strip, or may consist of lengths of backing joined by complete joint penetration butt welds. Butt welds in the backing material shall be tested in conformance with the requirements in AWS D1.5, Section 3.13.2. Butt welds in backing material shall be ground flush as necessary to obtain proper inspection and for proper fit-up in the weld joint with which the backing is to be used.

WELDING OF HPS485W STEELS

Welds between and to HPS485W steels shall conform to the requirements in this section. All welding procedures shall be qualified by testing in accordance with the requirements in AWS D1.5 as modified herein and shall be used within the qualified limits of heat input. Previously qualified welding procedures witnessed by the State may be submitted for review based on these specification requirements. Regardless of qualification range, the heat input, preheat temperature and maximum interpass temperature shall conform to the requirements of this section.

Consumables for welding HPS485W shall be low hydrogen with H2 or H4 designators as shown below. The Contractor shall test the actual level of hydrogen for each consumable using the proposed welding procedure and maximum exposure conditions anticipated during production as specified below. The level of hydrogen shall not exceed the limits specified below.

The following additional requirements shall apply when welding to HPS485W steel:

A. Only submerged arc and shielded metal arc welding are pre-approved for welding HPS485W steel. Consumable handling requirements shall be in accordance with the requirements of AWS D1.5-96, Section 12.6.

B. Filler Metal Requirements:

1. Filler metals for welds joining Grade HPS485W to Shear Link Grade 345 steels shall conform to the requirements listed in paragraph 2 below. Filler metals for welds between Grade HPS 485W and all other grades shall match the lower strength of the materials joined, unless noted otherwise on the plans.
2. Filler metals for matching fillet welds, and all groove welds connecting Grade HPS485W plates shall conform to the following requirements:

(a) Submerged Arc Welding (SAW) Consumables;
SAW consumables shall meet AWS Electrode/Flux Classification F9A4 EXXX-X with supplementary moisture resistance designators -H4 or -H2, in conformance with AWS A5.23, with 1% Nickel minimum in the weld deposit.

(b) Shielded Metal Arc Welding (SMAW) Consumables; E9018-RHZ* with 1% nickel minimum in the weld deposit.
(* the Designator 'R', for moisture resistant coating, is required for all SMAW electrodes used for welding HPS485W steels. HZ shall be either H2 or H4)

(c) Other Processes
No other processes will be permitted unless approved by the Engineer. Proposals shall include consumables and welding parameters. The use of other processes will be subject to approval by the Engineer based on proposed consumables and welding parameters and conformance to the testing requirements in the AISI/AASHTO Guide for Welding HPS Steel. Filler metals for other processes shall provide the properties specified below. Consumables shall have a low hydrogen designation of H2 or H4 and shall be moisture resistant. The Contractor shall perform the full ranges of tests required by AWS D1.5, Section 12.6 and diffusible hydrogen testing in accordance with AWS A4.3, "Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic and Ferritic Steel Weld Metal Produced by Arc Welding" to demonstrate that successful welds can be achieved with a maximum level of 4mL/100g of hydrogen. The diffusible hydrogen test is a required part of the procedure qualification testing for the project for consumable combinations that have not been successfully demonstrated in the AISI/AASHTO Project for Welding HPS 70W Steel for Bridges.

3. Except for single pass fillet welds, or welds that will be fully consumed in a finished weld with satisfactory weathering characteristics, welding consumables and electrodes shall produce weld deposits that meet the requirements of AWS D1.5, Table 4.3.
4. Qualification Testing: Weld procedure qualification test requirements for HPS485W groove welds shall be evaluated using Welding Procedure Specification (WPS) Test Plates from the greatest thickness to be welded in production and, for formed members, the as-formed base metal representing the highest forming strain, i.e., lowest ratio of diameter to thickness of a tubular, to be used in fabrication. Testing shall conform to AWS D1.5 qualification requirements, except fillet weld procedures shall be qualified in each position used, macroetch specimens shall be taken and additional sets of Charpy V-Notch specimens shall be taken within one millimeter of both the inside and outside tubular surfaces and centered on the coarse-grain heat affected zone (HAZ). The test results shall meet the following properties:

   Transverse tensile ultimate strength: ≥ 620 MPa
   All-Weld-Metal: yield strength: ≥ 485 MPa
   All-Weld-Metal: ultimate tensile strength: ≥ 620 MPa
   All-Weld-Metal: percent elongation: ≥ 19% in 50 mm
   Charpy V-Notch: as specified under Materials above.

5. In addition to the requirements for WPS qualification in accordance with AWS D1.5, diffusible hydrogen (Hd) tests shall be performed on weld metal that does not have H2 or H4 certification from the manufacturer. The deposited weld metal shall have a diffusible hydrogen level equivalent to 4 mL/100 g or less. Hd test specimens shall be prepared at the fabrication plant. Specimens shall be tested in accordance with AWS A4.3. Test results in excess of the specified limit are unacceptable, and a retest is required, with a revised welding or consumable control procedure. AWS D1.5, Section 5.7.6, "Exemption from Further Testing," is applicable, but WPS or Hd results are not transferable from fabricator to fabricator. Fabricators with multiple plants under a common umbrella of welding equipment, welding training, and supervision will be required to perform the Hd testing only once per combination of consumables for each location. Plants audited as a single facility by the American Institute of Steel Construction (AISC) as a part of their Quality Certification Program, or other Engineer approved equal Quality Assurance program, shall be considered one location. Multiple plants not falling under the AISC, or other 'single facility' audit definition, are considered separate facilities and additional WPS and Hd tests are required.

C. Preheat and Interpass Temperature:

1. The minimum preheat and interpass temperatures shall be in accordance with AWS D1.5, Table 4.4.

   If satisfactory results are not achieved with the above minimum preheat and interpass temperatures during development of the Welding Procedure Specification (WPS), and an increased preheat temperature is used to provide a satisfactory Procedure Qualification Record (PQR), the higher preheat temperature shall be used during fabrication as the required minimum.

   The minimum preheat or interpass temperature required for a joint composed of different base metals and/or different thickness shall be based on the highest of the minimum preheats required by AWS D1.5, Section Table 4.4.
2. The maximum interpass temperature for welding HPS485W steel is 230 ˚C.

D. Heat Input (HI);
   1.5 kilojoules per mm (kJ/mm), minimum
   3.5 kJ/mm, maximum
   as determined using AWS D1.5, Section 5.12.

E. Backing; AWS D1.5, Section 5.4.5 is modified to allow steel backing material for WPS test plates to be of grade 34550W (Sulfur = 0.025 max.) or HPS485W material.

WELDING OF GRADE 690 STEELS

Welds in Grade 690 steels shall conform to the requirements of AWS D1.5, as modified herein. All welding procedures shall be qualified by testing in accordance with the requirements in AWS D1.5 as modified herein and shall be used within the qualified limits of heat input. Previously qualified welding procedures witnessed by the State may be submitted for review based on these specification requirements. Regardless of qualification range, the heat input, preheat temperature and maximum interpass temperature shall conform to the requirements of this section.

Consumables for welding Grade 690 shall be low hydrogen with H2 or H4 designators. The Contractor shall test the actual level of hydrogen for each consumable using the proposed welding procedure and maximum exposure conditions anticipated during production. The level of hydrogen shall not exceed the limits specified below.

The following additional requirements shall apply when welding to Grade 690 steel:

A. Only submerged arc and shielded metal arc welding are pre-approved for welding Grade 690 steel. Consumable handling requirements shall be in accordance with the requirements of AWS D1.5-96, Section 12.6.

B. Filler Metal Requirements:

1. Filler metals for welds between Grade 690 steels shall conform to the requirements of AWS D1.5 for fracture critical members, as modified by paragraph 2 below. Filler metals for welds between Grade 690 and all other grades shall match the lower strength of the materials joined, unless noted otherwise on the plans.
2. Filler metals for matching fillet welds, and all groove welds joining Grade 690 steel shall conform to the following requirements:

(a) Submerged Arc Welding (SAW) Consumables;
SAW consumables shall meet AWS Electrode/Flux Classification F11A4 EXXX-X with supplementary moisture resistance designators -H4 or -H2, in conformance with AWS A5.23, with 1% Nickel minimum in the weld deposit.

(b) Shielded Metal Arc Welding (SMAW) Consumables; E11018-RHZ* with 1% nickel minimum in the weld deposit.
(* the Designator 'R', for moisture resistant coating, is required for all SMAW electrodes used for welding Grade 690 steels. HZ shall be either H2 or H4.

(c) Other Processes
The use of other processes will be subject to approval by the Engineer based on proposed consumables and welding parameters. Filler metals for other processes shall provide the properties specified below. Consumables shall have a low hydrogen designation of H2 or H4 and shall be moisture resistant. The Contractor shall perform the full ranges of tests required by AWS D1.5, Section 12.6 and diffusible hydrogen testing in accordance with AWS A4.3, "Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic and Ferritic Steel Weld Metal Produced by Arc Welding" to demonstrate that successful welds can be achieved with a maximum level of 4mL/100g of hydrogen. The diffusible hydrogen test is a required part of the procedure qualification testing for the project for consumable combinations that do not have H2 or H4 certification from the manufacturer.

3. Qualification Testing: Weld procedure qualification test requirements for Grade 690 groove welds shall be evaluated using Welding Procedure Specification (WPS) Test Plates from the greatest thickness to be welded in production and, for formed members, the as-formed base metal representing the highest forming strain, i.e., lowest ratio of diameter to thickness of a tubular, to be used in fabrication. Testing shall conform to AWS D 1.5 qualification requirements, except macroetch specimens shall be taken and additional sets of Charpy V-Notch specimens shall be taken within one mm of both the inside and outside tubular surfaces and centered on the coarse grain heat affected zone (HAZ). The test results shall meet the following properties:

   Transverse tensile ultimate strength: 760-900 MPa
   All-Weld-Metal: yield strength: ≥ 680 MPa
   All-Weld-Metal: ultimate tensile strength: ≥ 760 MPa
   All-Weld-Metal: percent elongation: ≥ 19% in 50 mm
   Charpy V-Notch: As specified under Materials above.

4. In addition to the requirements for WPS qualification in accordance with AWS D1.5, diffusible hydrogen (Hd) tests shall be performed on weld metal that does not have H2 or H4 certification from the manufacturer. The deposited weld metal shall have a diffusible hydrogen level equivalent to 4 mL/100 g or less. Hd test specimens shall be prepared at the fabrication plant. Specimens shall be tested in accordance with AWS A4.3. Test results in excess of the specified limit are unacceptable, and a retest is required, with a revised welding or consumable control procedure. AWS D1.5, Section 5.7.6, "Exemption from Further Testing," is applicable, but WPS or Hd results are not transferable from fabricator to fabricator. Fabricators with multiple plants under a common umbrella of welding equipment, welding training, and supervision will be required to perform the Hd testing only once per combination of consumables for each location. Plants audited as a single facility by the American Institute of Steel Construction (AISC) as a part of their Quality Certification Program, or other Engineer approved equal Quality Assurance program, shall be considered one location. Multiple plants not falling under the AISC, or other 'single facility' audit definition, are considered separate facilities and additional WPS and Hd tests are required.

C. Preheat and Interpass Temperature:

1. The minimum and maximum preheat and interpass temperatures shall be in accordance with AWS D1.5, Table 4.4.

   If satisfactory results are not achieved with the above minimum preheat and interpass temperatures during development of the Welding Procedure Specification (WPS), and an increased preheat temperature is used to provide a satisfactory Procedure Qualification Record (PQR), the higher preheat temperature shall be used during fabrication as the required minimum.

2. The minimum preheat or interpass temperature required for a joint composed of different base metals and/or different thickness shall be based on the highest of the minimum preheats required by AWS D1.5, Table 4.4Section 12.14.
3. The maximum interpass temperature for welding Grade 690 steel is 240 ˚C.

D. Heat Input (HI);
The heat input shall conform to the recommendations of the manufacturer, but is limited to the range qualified per AWS D1.5.

SHOP WELDING

Except as specified herein, welding, welder qualifications, and inspection of welding work shall conform to the requirements of AWS D1.5.

General Provisions

A. Steel fabrication shall conform to the requirements of AWS D1.5, except members designated on the plans as SPCMs, including welds connecting SPCM's to other members, shall be fabricated according to Chapter 12 of the AWS D1.5, "AASHTO/AWS Fracture Control Plan (FCP) for Nonredundant Members", except as modified in these special provisions.

B. To the extent that air movement may be harmful to welding procedures, ventilation in welding areas both during fabrication and erection shall be controlled to levels consistent with qualification procedures.

C. Welding of ancillary products – Connections of ancillary products, such as bikepath railings, to the main bridge elements shall be done by bolting. No structure which is welded to the box girder section or main elements of the bridge shall be considered ancillary. The provisions of AWS D1.5, Section 1.3.6, "Welding of Ancillary Products," shall not apply. The bikepath deck, and all its members shall be fabricated as a main element of the bridge and not as an ancillary product.

D. Welding of temporary fixtures such as lifting lugs or temporary shear enhancement devices shall be shown on the working drawings and shall conform to AWS D1.5. After removal, the structure shall be repaired as necessary to meet the requirements of these special provisions and AWS D1.5.

E. Gas Metal Arc Welding (GMAW), but not with short-circuiting transfer, will be permitted only for tack welding of structural members.

F. Electroslag (ESW) or electrogas (EGW) welding will not be permitted unless approved in writing by the Engineer. If the Contractor proposes to use electroslag or electrogas welding process at any location within the structure, a "Feasibility Review" proposal shall be submitted to the Engineer that includes the location, WPS, drawings of the joint fit-up, all welding aids, and documented evidence that the process has met the required mechanical properties, including toughness, and soundness criteria. If the Engineer approves the Feasibility Review proposal, then the Contractor shall submit to the Engineer for approval a complete ESW/EGW welding plan that includes the following.

    1. WPS
    2. PQR qualification test piece per AWS D1.5; Charpy V-Notch specimens shall be tested representing both the weld metal and coarse grain heat affected zone.
    3. Mock-up qualification test piece; A mock-up weld is required for each type of joint geometry as determined by the Engineer. Evaluation of the mock-up weld shall comprise NDT using the procedure that will be used in production, mechanical testing per Test Piece A of AWS D1.5 and 3 additional macroetch specimens taken at locations determined by the Engineer.
    4. All tolerances including finished weld profile
    5. All QC inspection hold points and report format
    6. Welding operator qualification reports
    7. All NDT procedures complete with details illustrating how the entire weld and heat affected zone shall be examined.
    8. Repair procedures for minor and major repairs.

    The NGI-ESW process, as developed in the Federal Highway Administration (FHWA) project, is the only ESW process that will be considered. Restarts in ESW or EGW welds will not be permitted.

Design Details

A. Unless otherwise shown on the plans or specifically approved in writing by the Engineer, all complete joint penetration (CJP) welds shall be back-gouged. Where backing bars are used, the backing bars shall be removed and the weld back-gouged and re-welded. The back gouged areas shall be ground to bright metal.

B. Weld backing shall conform to the requirements in AWS D1.5 and these special provisions.
C. Weld matching: Weld electrodes shall match the lower strength of the materials joined, except where otherwise noted.
D. Tightly adhering weld spatter shall be removed by power brush or grinding.
E. Gouging for back gouging or for repair shall be done by an approved arc method and /or by grinding. Oxygen cutting will not be permitted for any form of gouging. Procedures to avoid retention of carbon deposits, slag or dross shall be used. Air-carbon-arc gouged surfaces shall be ground or filed to bright metal.
F. Weld repairs – In addition to the provisions in AWS D1.5, Section 3.7.4, re-repair of welds or base metal requires prior approval of the Engineer. Repairs to SPCMs , including welds connecting SPCM's to other members, shall be as specified in AWS D1.5, "AASHTO/AWS Fracture Control Plan (FCP) for Nonredundant Member," Section 12.17, as modified herein.
G. Dimensional Tolerances

Dimensional control shall be performed in accordance with a written procedure that is approved by the Engineer before use. The dimensional control procedure shall describe how the required tolerances will be checked and achieved during fabrication and erection, including the sizing and use of dimensional control templates. Calculations shall be included to provide the basis for acceptance of interim dimensions of structures erected under temporary loading conditions, such as the box sections before installing the bikepath.

1. Dimensional tolerances shall conform to AWS D1.5 as modified on the plans and in these special provisions.
2. Where a discontinuous member provides a continuous load path on either side of a through member, the method of marking and ensuring alignment shall be described in the dimensional control procedure. Misalignment between discontinuous members shall not exceed 30% of the thickness of the thinner member or 2 mm, whichever is less.
3. Dimensional tolerances for the box girder shall conform to the tolerances in AWS D1.5, AASHTO Sixteenth Edition 1996, Division II – Construction, Section 11.4.13 – "Orthotropic Deck Superstructures," and the following:

    a. Fabricated assemblies, such as box girder segments, shall be checked against steel templates that are fabricated and measured to be true at the average bridge temperature, as shown on the plans and as approved by the Engineer. The templates shall simulate the in-place support conditions and permit the check and verification of all specified fabrication tolerances of the assembled box girder sections. The layout, design and construction of each template shall be subject to the Engineer's approval.
    b. Members comprising the box girder, including all internal structure, shall be straight within 5 mm for 5 m of box shell plate.
    c. The vertical web plates, transverse diaphragms and floor beam webs shall be within the plumbness and straightness tolerance in AWS D1.5 at any point along the member in the as-installed condition.
    d. The maximum offset of members restrained against bending shall be as specified in AWS D1.5, Section 3.3.3.
    e. At each end of each box girder segment, the box shell plates shall be within 1.5 mm of a template that is fabricated to match the bridge dimensions at the average bridge temperature shown on the plans. At these ends, the ribs shall be within 2 mm of the theoretical position as defined by a template or other equally positive method. The total misalignment across a bolted rib splice shall not exceed 1.5mm.

f. Rib sweep shall not exceed 4 mm between floor beams. The spacing between closed rib stems or between adjacent ribs shall not exceed a tolerance of 4 mm.
g. Box shell plates terminating at a cross beam web shall be aligned within 1 mm. The alignment shall be determined using a straightedge at all longitudinal rib cutouts.
h. The continuity plate within the closed ribs shall match the diaphragm plate within a 1 mm tolerance. A 3 mm tolerance may be used instead providing the continuity plate thickness is increased by 4 mm at no cost to the State.

4. The dimensional tolerances for the fabrication, assembly and erection of the tower shall conform to the tolerances in AWS D1.5 and the following:

A. Each shaft of the tower shall be plumb within 1 mm in 2500 mm. In addition, the out-of-plumbness of each tower lift shall not exceed 1 mm in 1000 mm.
B. The longitudinal, transverse and diagonal distances between any two tower shaft corners AE shall not exceed a tolerance of 1 mm in 250 mm. This tolerance shall be measured at elevation 28.0 m, at all tower cross bracing elevations, and at the tower saddle grillage elevation."

C. The tolerance on the location of the corners of the tower shaft segment ends along the height of the tower shall be as follows:

Corner	AE	AB	BC	CD	DE
Elevation at 3.125m	5 mm	5 mm	5 mm	5 mm	5 mm
All other locations	5 mm	10 mm	15 mm	15 mm	10 mm

Note that the above tolerances are relative to the plumbness tolerances of 1 mm in 2500 mm on the tower shaft.

D. At each tower strut location, the relative vertical location of the shear link connection between adjacent tower shafts shall not exceed 10 mm. A maximum of 10 mm thick shim plates may be used at the flange splice plates so that the shear links are level to 1 mm in 2500 mm after they are connected to the tower shafts. The elevation of each diaphragm shall be within 10 mm of the theoretical elevation. All modified connections shall be subject to review and approval by the Engineer.
E. The tolerance on the location of the tower base plate is 10 mm with respect to the as-built foundation.
F. The misalignment at bolted or welded vertical tower stiffener splices shall not exceed 2 mm. Splice plates shall be aligned within 1.5 mm at each end to the installed stiffener plates.
G. The top surface of the grillage top plate shall be flat to within a tolerance of 1/1000.
H. The tolerance for the total height of the tower is 75 mm and shall be taken after tower construction is completed and before cable erection.
I. The tolerance of the tower anchorage anchor bolt holes shall be –0/+2 mm.
J. The tolerance for the distance between tower anchorage anchor bolt centers is 2 mm. This tolerance is relative to the working drawings for the as-fabricated tower footing provided by the State.
K. The tolerance for the tower anchorage anchor bolt stiffeners is ±3 mm
L. The tolerance of the gap for longitudinal stiffener bolted splice is –0/+2 mm.
M. The straightness of each tower lift, tower segment and tower skin plate/longitudinal stiffener between diaphragms shall satisfy the requirements of AWS D1.5-02 Section 3.5.
N. The tolerance on the location of the longitudinal stiffeners in the tower shaft and tower anchorage shall be 2 mm.

Welding of Closed Ribs to Box Shell Plate

A. Welding of closed ribs to box shell plates shall be accomplished with a welding process and procedure that achieves a minimum of 80% penetration of the rib thickness. Only SAW automated welding process shall be used. Closed ribs shall be clamped or tack welded in place, and both stems welded to the deck plate simultaneously. The Contractor's proposed process and rib groove detail shall undergo trials to obtain the optimum joint detail as defined below. In addition to these tests, the qualification procedure required by AWS D1.5 shall be followed. Production welding, with any of the processes tried, will not be permitted without the approval of the Engineer. Repair welding methods and procedures shall be approved by the Engineer.

B. Weld Procedure Trials– For closed rib welds to the deck plate, the Contractor shall perform weld trials on the mock-up using the mechanized SAW welding system that will be used in production. The qualification trial shall be run with the same number of ribs that will be run in production. The full number of macro specimens defined below shall be taken from a rib selected by the Engineer. All other ribs shall have 3 macros taken from each weld at locations selected by the Engineer.

Tack welding shall be considered as part of the weld qualification, including size and location of tacks, limits on essential variables and other qualification limitations. Tack welding shall be automated unless approved otherwise in writing by the Engineer, in which case the UT inspection of production welds shall be 100%.

The trials shall be conducted with welding machines, parameters, root openings and bevels as shown in the approved WQCP. Pre-bending, or other measures that will be used to control distortion during production, shall be defined and used during the trials. The weld trial shall be performed on the ribs of the mock-up. If tack welds will be used during production, tack welds shall be made at the maximum spacing to be used in production and prepared as will be done during production. During these trials, the welding shall be stopped at every 2.0 meters, and then restarted.

At completion of welding of all closed ribs to deck plate, the welded panels shall be checked for straightness and other production tolerances. The welded, unstraightened panel shall be flat within 1 in 500. If the unstraightened panel is not flat within 1 in 500, new measures such as different prebending or fixturing, shall be proposed, and new trial panels welded. If the flatness requirement is satisfied, all remaining plates of the deck plate section shall be welded on to complete the steel mock-up. Testing of the closed rib welds shall be conducted after welding of all components of the mock-up have been completed.

For panels that meet the visual and dimensional tolerance requirements, the welds shall be 100% ultrasonically tested to verify the required 80% penetration. The rib shall then be split in two and both stems shall be examined, after cutting and macroetching at anomalies as determined by UT and selected by the Engineer, but at least at the ends of the rib, at each tack weld and re-start locations and at intermediate points. At two tack weld locations on each weld, three macrosections shall be taken that represent the start, middle and end of the tack weld. Hardness tests shall be performed on these macrosections.

The evaluation criteria for the macroetched sections is as follows:

1. The minimum depth of penetration shall be 80% of the rib thickness, except that a depth of penetration not less than 70% of the rib thickness is permitted for isolated locations not exceeding 5% of the weld length, or 10% of the number of macro specimens, providing the effective weld size exceeds 80% of the rib thickness and all other requirements are satisfied.
2. The minimum partial penetration groove effective weld size shall be 80% of the rib thickness. For this evaluation, the effective weld size shall be defined as the smallest distance from any point at the root to an outside weld or plate surface, as measured in a macroetch section.

3. No gross notches or burn-through will be permitted at the rib inside surface, although uniform melt-through of reinforcement is acceptable. Melt-through or root reinforcement internal to the closed rib may have overlap not exceeding 2 mm. A gross notch is defined as an abrupt change of internal root reinforcement reentrant angle that is less than 90 degrees in any direction.
4. A uniform reinforcement fillet of between 2 mm and 5 mm shall be included.
5. The exterior surface profile shall meet AWS D1.5, Section 6.26.1 for a weld in a primary member with tension transverse to the weld axis. A maximum of 0.25mm undercut is permitted.
6. Tack welds shall be incorporated into the final weld and shall not result in hard spots; uneven transverse notches; cracks or tears; or excessive thickness that results in local weld thickness variations greater than 3 mm.

Hard spots shall be determined by Vickers hardness measurements taken at 2mm centers in the tack weld heat affected zones of both base plate and rib on the tack weld macrosections specified above. A hard spot shall be defined as a hardness value in the tack weld HAZ that exceeds 15% of the adjacent heat affected zone.

The worst of these macrosections that is acceptable to the Engineer will be considered qualified welds and will be used as standards for acceptance of production welds as monitored during fabrication.

C. Monitoring of Production Welds – During fabrication, weld monitoring tests shall be conducted for each operator on each welding machine at the start of each work shift. Test specimens shall consist a separate piece of deck plate and rib. The rib shall be tack welded to the test piece the same as on the panel. Run-on and run-off tabs may be used if used in the production plates. If the equipment is used in production to simultaneously weld multiple ribs, then at least two ribs shall be welded during the test. The specimen shall be at least 500 mm long, and shall be examined 100% by UT. The specimen shall be macroetched 25 mm from each end, at a tack weld, and at two intermediate locations, as determined by the Engineer, immediately after welding.

In the event that the monitoring test specimens do not provide quality similar to those originally developed and accepted, fabrication shall cease. The welding parameters shall then be adjusted and production of qualified welds verified through two consecutive successful additional specimen trials approved by the Engineer before fabrication of deck panels is allowed to continue with the welding machine being monitored.

D. Panel Production – The dimensions of production panels of box shell plating shall be checked after welding. The welded panel, after straightening, if any, shall be flat within 5 mm in each 5 m length of box panels. Panels may be straightened using a written procedure that is in conformance to AWS D1.5 and is approved by the Engineer.

Ultrasonic technician shall be qualified using a mock-up weld with flaws that is approved by the Engineer.

If more than one panel in five requires straightening by more than 15 mm after welding, the Contractor shall propose a revised assembly procedure, such as a different amount of pre-bending, and shall demonstrate the revised method by welding a new panel in the presence of the Engineer.

Production panels shall be tested by ultrasonic examination at the rate specified below. Inspection of the PJP weld shall be in accordance with a written procedure that includes representative calibration standards with a 1.5 mm notch on the rib side and the plate side of the weld; that is demonstrated on a prototype panel segment that includes known flaws; and that is approved by the Engineer before use. Each

WELDING PROCEDURE QUALIFICATION

A. Qualification of Welding Procedure – Qualification testing shall be conducted for all welds and weld details as specified hereunder. Procedure qualification records (PQR) pertaining to tests conducted within the last 30 months, witnessed by Caltrans, and certified to be accurate will be accepted if the test material thickness was equal to or greater than the material to be used on the project, and the properties and qualification details meet the requirements of these special provisions. Otherwise, new tests shall be conducted. Qualification tests shall be performed in accordance with AWS D1.5 except that the thickness of the test plate shall not be less than the maximum thickness to be welded using the qualified procedure. Groove weld macroetch tests per AWS D1.5 are required for qualification of all complete joint penetration and partial joint penetration weld joint details not specified in AWS D1.5, Figure 2.4 or Figure 2.5.

Unless otherwise specified herein, the ductility requirements shall be 22% elongation for a gage length of 50 mm in the reduced section of the reduced section tension specimens. The Charpy V-Notch impact toughness requirements for weld metal are stipulated above under "Materials" or in AWS D1.5 if not specified therein. Charpy V-Notch impact tests shall also be taken from the coarse grain heat affected zone (HAZ) for steels with HAZ toughness requirements stipulated above under "Materials."

INSPECTION AND TESTING

The Contractor shall provide the Engineer with work schedules, and expected readiness of work for quality assurance (QA) inspection by the Engineer. The Contractor shall maintain records of all QC testing and measurements specified and such records shall be made available to the Engineer upon request, unless otherwise specified.

Full access shall be provided for the Engineer to conduct VT for not less than 60 hours from the time the weld is completed.

Magnetic particle examination shall be performed using the yoke method for all steel grades with a specified minimum yield strength of 485 MPa or more.

All welds shall receive 100% visual examination. Visual inspection shall not be considered a NDT method. The extent of non-destructive examination is specified below, unless specified elsewhere in these special provisions.

This table supercedes AWS D1.5, Sections 6.7.1 and 6.7.2.

COMPONENT	Weld Type			Extent & Type of Testing			Notes
	CJP	PJP	Fillet	RT	UT	MT	
1.BOX GIRDER 1.1 Box Shell							
Transverse splice weld shop (Deck plate: A) field	X X			5% 5%	100% 100%	 100%	
Transverse splice weld shop (Side plate: B,F) field	X X			5% 5%	100% 100%	 100%	
Transverse splice weld shop (Bottom plate: D) field	X X			5% 5%	100% 100%	 100%	
Transverse splice weld shop (Side plate: C,E,G,H,I,L,M,N, "K" &"Vertical") field	X X				** **		
Transverse splice weld shop (Bottom plate: D) field	X X			5% 5%	100% 100%	 100%	
Transverse splice weld shop (Side plate: B,C,E,F,G,H,I,L,M,N, "K" &"Vertical") field	X X				** **		
Longitudinal weld: Deck plate: A	X			15%	100%		
Longitudinal splice weld (Bottom plate: D)	X				100%		
Longitudinal splice weld (Side plate: C,E,G,H,I,L,M,N, "K" &"Vertical")	X				100%		(B & F are n/a)
Box corner welds	X	 X	 X		100%	 100%	
Closed rib splice	X				100%		
Closed rib to shell plate: Tack welds automated Tack welds not automated		 X X			 15% 100%	 25% 25%	
Open rib to box plate			X			15%	

Floorbeam to Deck plate	X		X		100%	50%	
Floorbeam to Deck plate			X			25%	
Floorbeam to other box shell plates At Crossbeam penetrations Elsewhere	X	X	X X		100%	25% 10%	
Longitudinal Shear Plate to Deck Plate			X			25%	
Longitudinal Shear Plate to other Box shell plates			X			10%	
Deck plate to drain plates	X				15%		
Deck plate transverse splice at Seismic Joint	X	X			100% 100%		
Diaphragm plate to closed rib	X	X			100%	100 %	Tension acceptance criteria for PJP weld
1.2. Box Internal Stiffening							
Floorbeam splice: Bottom 1 m Remainder of lower half Upper half	 X X X				 100% 50% 15%		
Floorbeam Diaphragm to rib	X	X	X			100% 25%	
Floorbeam Vertical splice: Lower half Upper half	 X X				** 100% 15%		
Floorbeam Diaphragm to rib	X		X		100%	25%	
Ground end of diaphragm to closed rib weld for full length of grinding plus 50mm each end	X	X	X			100%	Additional to NDT specified for weld
Longitudinal Shear Plate to Floorbeam	X	X	X		100%	15%	
Longitudinal Shear Plate Vertical splice	X				**		
Longitudinal Shear Plate to top and bottom plate	X		X			15% 15%	

1.3. Girder at Piers							
All SPCM welds	X	X	X	15%*	100% 100%	100%	* RT+UTfor butt welds (% shown) & butt repairs (100%)
Non-SPCM Welds	Per Sections 1.1, 1.2 & 1.5 of this Table						
Saddle Grillage welds	X	X	X		25%	25%	
Saddle welds	X	X	X		25%	25%	
1.4 Hinge K							
1900 dia tube Longitudinal & Girth welds	X			100%	100%	100%	
Ring Stiffener & End Plate to 1900 dia tube	X				100%	100%	
Radial Bearing Plates to 1900 dia tube	X				100%	100%	
Other Hinge and Hinge back-up welds	X	X	X		100%	25% 25%	
Stainless steel overlay plus 100mm of tube at each end of overlay							100% PT per AWS D1.6
1.5 Other box welds							
SPCM Cable Bracket welds	X	X	X	15%*	100% 100%	100%	* RT+UTfor butt welds (%) & butt repairs (100%)
Deviation & Jacking Frame Saddles: Plates to Castings	X	X	X		100%	100% 25%	
Deviation & Jacking Frame Saddles: Plate welds	X	X	X		100%	25%	

Other Welds in SPCMs	X	X	X	15%*	100% 100%	100%	* RT+UTfor butt welds (% shown) & butt repairs (100%)
Other welds	X	X	X		25%	10% 10%	
Ends of welds at locations of required grinding for full length of grinding plus 50 mm each end	X	X	X			100%	Additional to NDT specified for weld
2. CROSSBEAM							
All SPCM Welds	X	X	X	15%*	100% 100%	100%	* RT+UTfor butt welds (% shown) & butt repairs (100 %)
Other welds	X	X	X		25%	10% 10%	
Ends of welds at locations of required grinding for full length of grinding plus 50 mm each end	X	X	X			100%	Additional to NDT specified for weld
3. TOWER							
Skin plate butt welds: Horizontal	X				100%		
Skin plate butt welds: Vertical	X				100%		
Longitudinal Stiffener butt welds	X				100%		
Longitudinal stiffener to skin plate	X	X	X		100% 50%	25%	
Diaphragm butt welds	X				100%		
Diaphragm to Skin Plate	X	X	X		100% 50%	25%	
Diaphragm to Longitudinal Stiffener (incl. Fit Lugs)	X	X	X		100% 25%	25%	

Tower Strut Welds & Cross Bracing Welds	X	X	X	15%*	100% 100%	100% 100% 100%	* RT+UTfor butt welds (% shown) & butt repairs (100%)
Grillage welds	X	X	X		100% 25%	25%	
Tower Saddle welds	X		X		100%	100% 100%	
Skin Plate to Tower Base Plate	X				100%		
Bearing Stiffener Welds at Tower Base Anchor Bolt Assemblies	X	X	X		25%	25%	
Other SPCMcomponents	X	X	X	15%*	100% 100%	100% 100% 100%	* RT+UTfor butt welds (% shown) & butt repairs (100%)
Other Tower welds	X	X	X		25%	10% 10%	
OTHER WELDS NOT SPECIFIED ABOVE							
Welds in SPCMs	X	X	X	15%*	100% 100%	100% 100% 100%	* RT+UTfor butt welds (% shown) & butt repairs (100%)
Other welds	X	X	X		25%	10% 10%	
Ends of welds at locations of required grinding for full length of grinding plus 50mm each end	X	X	X			100%	Additional to NDT specified for weld

Notes:

1) Vertical butt joints marked ** in the table shall be tested as follows:
   (a) 1/6 of the web depth beginning at each end of weld, unless otherwise noted, shall be tested 100 %
   (b) 25 % of the remainder shall be tested.

2) If unacceptable discontinuities are found in a joint with 100% NDT, the repairs shall be completed and then re-examined by the same NDT method along with an additional 50 mm at each end of the weld repair, for a minimum total additional length of 100 mm.
3) If unacceptable discontinuities are found in a joint with a specified percentage of testing of NDT less than 100 %, including RT examination of butt weld repairs, the repairs shall be completed and then re-examined by the same NDT method along with an additional 50mm at each end of the weld repair, for a minimum total additional length of 100mm for the repair re-examination. Two additional previously untested segments, each at least 10% of the total weld length, on each side of the repair, for a total additional length of 20%, shall be tested with the same NDT method. If additional unacceptable discontinuities are found as a result of this testing, then 100% of the remaining untested portion of the weld shall be tested with the same NDT method. All weld repairs shall be tested with the same NDT method that located the original defect.
4) Where the specified percentage of testing is greater than 25%, the specified length of each weld shall be tested.
5) Where the specified percentage of testing is 25 %, each weld that is 1.5 m long or more shall be examined over 25 % of the weld length. Welds under the same table category in the same component that are less than 1.5 m long may be lot examined by testing one weld 100 % for each lot of four welds.
6) Where the specified percentage of testing is 15 %, each weld that is 2.5 m long or more shall be tested over 15 % of the weld length. Welds under the same table category in the same component that are less than 2.5 m long may be lot examined by testing one weld 100 % for each lot of seven welds.
7) Where the specified percentage of testing is 10 %, each weld that is 4.0 m long or more shall be examined over 10 % of the weld length. Welds under the same table category in the same component that are less than 4.0 m long may be lot examined by testing one weld 100 % for each lot of ten welds.
8) For lot examination, if unacceptable discontinuities are found in the weld tested, the remainder of that weld shall be tested, and a second weld in the lot will be chosen by the Engineer and shall be tested. If unacceptable discontinuities are found in the second weld, the entire lot shall be tested.
9) UT examination of PJP welds shall confirm the specified weld size and, for weld sizes greater than 15mm, shall also evaluate the accessible weld volume to the requirements of AWS D1.5 for welds in compression.
10) Welds, and adjacent parent material within 10 mm of all accessible areas surrounding the weld, in grades with strength levels of 485 and above shall be tested 100% by MT in addition to other specified inspection. The timing of visual and any method of NDT for welds in these steels shall be in accordance with AWS D1.5, Section 12.16.4.
11) Welds made by either the electroslag or electrogas processes shall be examined 100% by both radiographic and ultrasonic testing.
12) Scanning for ultrasonic examination of corner, tee and cruciform welds in thicknesses greater than 50 mm shall include base metal behind and adjacent to the welds. Lamellar tearing discontinuities that exceed 3 mm or that lie within 10 mm of the surface shall be repaired.
13) SPCMs shall include welds connecting SPCM's to other members."

Acceptance

For purposes of acceptance, all CJP welds shall be considered to sustain tension, except for those otherwise shown on the plans. PJP and fillet welds shall meet the acceptance criteria for welds in compression, except as specified for the orthotropic deck.

Pressure Test

Where a pressure test is specified on the plans, such as to verify the integrity of closed rib sections, the air tightness of the enclosed area shall be pressure tested. The air pressure used for the test shall be 0.2 bar. The enclosed area shall be pressurized, and then isolated by closing the fill valve. Valves shall be placed in the end diaphragm of the rib. A calibrated pressure gage with suitable precision shall be monitored over a period of 2 hours. The pressure shall not drop by more than 10%. Compensation for pressure variations due to temperature changes shall be permitted within a range of 5 degrees Centigrade.

Five percent of the total number of rib spaces within each panel shall be leak tested. If leaks are detected, all of the rib spaces within the panel shall be subjected to leak testing. The Contractor shall repair the defects at the Contractor's expense.

FIELD WELDING

Field fabricators and erectors shall be certified under the AISC Quality Certifications Program, Category CASE, Certified Advanced Steel Erector.

Field welding shall comply with all provisions under "Shop Welding," of these special provisions.

All joints that are to be field welded shall be protected from corrosion and contaminants during storage, shipping, and until the joints are ready to be welded.

If, during the NDT of field welding, the rejection rate exceeds 10% of the tested length, the Engineer shall have the authority to stop work and request a formal report from the Contractor stating the reason for the defects and a plan to prevent these defects from reoccurring. No compensation will be made to the Contractor for any delays caused by this stoppage of work.

The Contractor shall provide suitable enclosures to permit field welding during inclement weather, which includes local wind speeds in the vicinity of the weld exceeding that specified in AWS D1.5, or 30 kilometer per hour, whichever is less. Field welds for the tower, box girder and crossbeams shall be performed in suitable enclosures that protect the weld area from winds and other deleterious environmental exposure, as approved by the Engineer. Provisions shall be made to control atmospheric conditions inside the enclosures with limits suitable for field welding in accordance with the requirements of AWS D1.5 and "Welding" of these special provisions.

No extension of contract time will be granted and no additional compensation will be allowed as a result of weather conditions which exceed the limits for field welding designated herein, except as approved by the Engineer.

GMAW for field welding will not be permitted.

Field welding of tower, crossbeam and box lifts shall conform to the following.

A. Mechanized processes such as SAW or automated FCAW are required for field welding of the tower skin and crossbeam and box shell plates unless otherwise approved by the Engineer.
B. The sequence of welding and bolting shall follow the approved fabrication procedure.
C. For welds with required preheat temperatures greater than 65° C, preheat temperatures shall be achieved and maintained using electric resistance heating bands for the entire length of the weld. The heaters shall be controlled by attached thermocouples at spacing not exceeding 2 m. For these welds, the minimum preheat temperature shall be maintained continuously from beginning to completion of the entire weld, even if welding is interrupted.
D. Steel backing shall be removed, and the back side cleaned to sound metal and welded, unless shown otherwise on the Plans or approved by the Engineer.
E. The final weld surface shall be ground smooth and flush. The direction of final grinding marks shall be parallel to the axis of the tower or bridge.
F. The timing of final visual and nondestructive examination shall be in accordance with AWS D1.5, Section 12.16.4.
G. The minimum preheat for field welding of deck/shell plating for box and crossbeam lifts shall be 50°C more than the AWS D1.5, Table 4.4 requirement.
H. Welding procedures for field welding of deck/shell plating for box and crossbeam lifts shall be qualified with a minimum of three strongbacks that are a minimum of 20 mm thick to simulate the restraint during the field welding.

MEASUREMENT AND PAYMENT

Payment for structural steel shall conform to the provisions in Section 55-4.02, "Payment," of the Standard Specifications and these special provisions.

Structural steel for use in bridge structures will be paid for at the contract price per kilogram for furnish structural steel and the contract price per kilogram for erect structural steel of the types listed in the Engineer's Estimate, except as noted.

The contract price paid per kilogram for furnish structural steel of the types listed in the Engineer's Estimate shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in furnishing, fabricating and delivering structural steel to the job site, ready for erection, including furnishing all bolts, nuts and washers, stud connectors, welding materials, asbestos sheet packing, preformed fabric pads and elastomeric bearing pads, or other materials required for the erection and connection or splicing of the structural steel; galvanizing the structural steel when galvanizing is required by the specifications or plans; and conforming to the qualification and testing requirements associated with member fabrication; as shown on the plans, as specified in the Standard Specifications and these special provisions, and as directed by the Engineer.

The contract price paid per kilogram for erect structural steel of the types listed in the Engineer's Estimate shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in erecting the structural steel, complete in place, including connecting and splicing the structural steel; installing stud connectors; placing asbestos sheet packing, preformed fabric pads and elastomeric bearing pads; furnishing and applying caulk; furnishing and placing mortar for masonry or bearing plates and anchor bolts; checking bolt tension; and conforming to qualification and testing requirements associated with member erection, connection or splicing; as shown on the plans, as specified in the Standard Specifications and these special provisions, and as directed by the Engineer.

Furnish structural steel (bridge) and erect structural steel (bridge) shall include the following items of work:

A. West jacking frame
B. Closure Joint
C. West deviation saddle housing
D. Extra-strong steel pipe for the cable tie-down
E. East saddle housing
F. Pier E2 bearing anchor rods

Light support materials and luminaire support boxes attached to the box girder will be measured and paid for as furnish structural steel (bridge)(box girder) and erect structural steel (bridge)(box girder).

Light support materials and luminaire support boxes attached to the bikepath will be measured and paid for as furnish structural steel (bridge)(bikepath) and erect structural steel (bridge)(bikepath).

Installation of metal benches at the East-end belvedere of the bikepath will be measured and paid for as erect structural steel (bridge)(bikepath).

Spare tower struts will be measured by the unit as furnish structural steel (bridge) (tower strut).

The contract unit price paid for furnish structural steel (bridge) (tower strut) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in furnishing, fabricating and delivering spare structural steel tower struts to the location specified by the Engineer, including cleaning and painting, and conforming to the qualification and testing requirements associated with member fabrication, as shown on the plans, as specified in the Standard Specifications and these special provisions, and as directed by the Engineer.

The contract price paid per kilogram for furnish structural steel (bridge) (saddle) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in furnishing, fabricating and delivering structural steel to the job site, ready for erection, including furnishing all bolts, nuts and washers, tie-rods, studs, welding materials, and any other materials required for the erection and connection or splicing of the structural steel saddles and conforming to the qualification and testing requirements associated with saddle fabrication; as shown on the plans, as specified in the Standard Specifications and these special provisions, and as directed by the Engineer.

The contract price paid per kilogram for erect structural steel (bridge) (saddle) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in erecting the structural steel saddles, complete in place, including connecting and splicing the structural steel saddles; installing bolts; checking bolt tension; and conforming to qualification and testing requirements associated with member erection, connection or splicing; as shown on the plans, as specified in the Standard Specifications and these special provisions, and as directed by the Engineer.

Spare pipe beam fuses will be measured by the unit as furnish structural steel (bridge) (pipe beam fuse).

The contract unit price paid for furnish structural steel (bridge) (pipe beam fuse) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in furnishing, fabricating and delivering spare structural steel pipe beam fuses to the location specified by the Engineer, including cleaning the painting, and conforming to the qualification and testing requirements associated with member fabrication, as shown on the plans, as specified in the Standard Specifications and these special provisions, and as directed by the Engineer.

Installation of pipe beams for Hinges AW and AE will be measured by the unit as install structural steel (bridge) (pipe beam).

The contract unit price paid for install structural steel (bridge) (pipe beam) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in installing structural steel pipe beams at Hinges AW and AE, as shown on the plans, as specified in the Standard Specifications and these special provisions, and as directed by the Engineer.

Full compensation for providing and maintaining enclosures to permit field welding shall be considered as included in the contract prices paid per kilogram for furnish structural steel, of the types listed in the Engineer's Estimate, and no additional compensation will be allowed therefor.

Full compensation for mock-ups and welding qualification procedures and testing shall be considered as included in the contract prices paid per kilogram for furnish structural steel, of the types listed in the Engineer's Estimate, and no additional compensation will be allowed therefor.

Full compensation for furnishing and installing HDPE pipe shall be considered as included in the contract prices paid per kilogram for furnish structural steel, of the types listed in the Engineer's Estimate, and no additional compensation will be allowed therefor.

Full compensation for repairing damaged paint surfaces shall be considered as included in the contract prices paid per kilogram for erect structural steel, of the types listed in the Engineer's Estimate, and no additional compensation will be allowed therefor.

Full compensation for prestressing high-strength A354 bolts shall be considered as included in the contract price paid per kilogram for erect structural steel, of the types listed in the Engineer's Estimate, and no separate payment will be made therefor.

The sixth paragraph of Section 55-4.02 "Payment," of the Standard Specifications shall not apply.

If a portion or all of the structural steel is fabricated more than 480 air line kilometers from both Sacramento and Los Angeles, additional shop inspection expenses will be sustained by the State. Whereas it is and will be impracticable and extremely difficult to ascertain and determine the actual increase in these expenses, it is agreed that payment to the Contractor for furnishing the structural steel from each fabrication site located more than 480 air line kilometers from both Sacramento and Los Angeles will be reduced $5000 or by an amount computed at $0.044 per kilogram of structural steel fabricated, whichever is greater, or in the case of each fabrication site located more than 4800 air line kilometers from both Sacramento and Los Angeles, payment will be reduced $8000 or by $0.079 per kilogram of structural steel fabricated, whichever is greater.

If a portion of or all check samples are removed at a mill more than 480 air line kilometers from both Sacramento and Los Angeles, shop inspection expenses will be sustained by the State which are in addition to expenses incurred for fabrication site inspection. Payment to the Contractor for furnishing structural steel will be reduced $2,000 for each mill located more than 480 air line kilometers from both Sacramento and Los Angeles.

10-1.62 CLEAN AND PAINT STRUCTURAL STEEL

Exposed new metal surfaces shall be cleaned and painted in conformance with the provisions in Section 59-2, "Painting Structural Steel," and Section 91, "Paint," of the Standard Specifications and these special provisions. Exposed surfaces include all surfaces exposed to the atmosphere.

Section 59-2.01, "General," of the Standard Specifications is amended by adding the following paragraph after the first paragraph:

- Unless otherwise specified, painting Contractors or subcontractors shall be required to have the following certifications from the "SSPC: The Society for Protective Coatings" (formerly the Steel Structures Painting Council), prior to performing the work:

  A. For cleaning and painting of structural steel in the field, certification in conformance with the requirements in Qualification Procedure No. 1, "Standard Procedure For Evaluating Painting Contractors" (SSPC-QP 1).
  B. For the removal of paint from structural steel, certification in conformance with the requirements in Qualification Procedure No. 2, "Standard Procedure For Evaluating The Qualifications of Painting Contractors To Remove Hazardous Paint" (SSPC-QP 2).
  C. For cleaning and painting of structural steel in a permanent painting facility, certification in conformance with the requirements in Qualification Procedure No. 3, "Standard Procedure For Evaluating Qualifications of Shop Painting Contractors" (SSPC-QP 3). The AISC's Sophisticated Paint Endorsement (SPE) quality program will be considered equivalent to SSPC-QP 3.

Whenever the Standard Specifications refer to "Steel Structures Painting Council," the reference shall be replaced with "SSPC: The Society for Protective Coatings."

Attention is directed to “Metallizing” of these special provisions for surface coating the inside of saddle troughs.

The Contractor shall provide suitable enclosures to permit cleaning and painting during inclement weather. Provisions shall be made to control atmospheric conditions inside the enclosures within limits suitable for cleaning throughout the cleaning operation, painting throughout the painting operation, drying throughout the drying period to solvent insolubility, and throughout the curing period per the manufacturers’ recommendations and these special provisions. Full compensation for providing and maintaining such enclosures shall be considered as included in the prices paid for the various contract items of work requiring paint and no additional compensation will be allowed therefor.

No extension of contract time will be granted and no additional compensation will be allowed as a result of temperature or humidity which exceeds the limits for cleaning or painting designated herein, except as approved by the Engineer.

The Contractor shall ensure that all cleaning and painting operations are done in conformance with the coating manufacturer's requirements. A manufacturer's representative shall be present to provide technical assistance during all cleaning and painting operations. The manufacturer shall provide written instructions that include recommendations for cleaning, painting, drying, curing, handling, shipping, and storage of coated steel. These instructions shall be available for review at the pre-painting meeting. The manufacturer's representative shall provide monthly written certification as to the Contractor's conformance with the manufacturer's requirements. If there is a conflict between the manufacturer's requirements and those specified herein, the conflicts shall be discussed at the pre-painting meeting and the Engineer shall be the final judge as to which requirements shall prevail.

Full compensation for services of the manufacturer's technical representative shall be considered as included in the contract price paid for the various items of work involved and no separate payment will be allowed therefor.

APPLICATION

Application of coatings shall be done in conformance with the requirements of SSPC-PA 1.

Fresh, potable water with a maximum chloride content of 75 mg/L and a maximum sulfate content of 200 mg/L shall be used for water rinsing or pressure washing operations. Water shall be single use; no continuous recycling of rinse water will be permitted. If rinse water is collected into a tank and subsequent testing determines that the collected water conforms to specified requirements, reuse may be permitted at the discretion of the Engineer, as long as no collected water is added to the tank after sample collection for determination of conformance to specified requirements. Water from water rinsing operations shall not be permitted to enter the bay, fall on public traffic, flow across shoulders or lanes occupied by public traffic, or to flow into gutter or other drainage facilities. Water rinsing is defined as a pressurized water rinse with a minimum nozzle pressure of 35 MPa and a minimum flow rate of 15 liters per minute.

Prior to submitting the Painting Quality Work Plan (PQWP) required herein, a pre-painting meeting between the Engineer, the Contractor's QCM, a representative from each entity performing painting for this project, and a representative from the manufacturer to provide the paint, shall be held to discuss the requirements for the Painting Quality Work Plan.

Prior to performing any painting or paint removal, the Contractor shall submit to the Engineer, in conformance with the provisions in "Working Drawings," of these special provisions, 3 copies of a separate Painting Quality Work Plan (PQWP) for each item of work for which painting or paint removal is to be performed. As a minimum, each PQWP shall include the following:

A. The name of each entity performing painting or paint removal.
B. One copy each of all current "SSPC: The Society for Protective Coatings" specifications or qualification procedures, and one copy of all ASTM Standards which are applicable to the painting or paint removal to be performed. These documents shall become the permanent property of the Department.
C. A copy of the manufacturer's guidelines and recommendations for cleaning, painting, drying, curing, handling, shipping, and storage of the product.
D. Proposed methods and equipment to be used for any paint application.
E. Proof of each of any required certifications, SSPC-QP 1, SSPC-QP 2, SSPC-QP 3, AISC SPE.
F. Proposed methods to control environmental conditions in accordance with the manufacturer's recommendations and these special provisions.
G. Proposed method to protect the product during curing, shipping, handling, and storage.
H. Proposed rinse water collection plan.
I. For all coatings, the PQWP shall contain the manufacturer's written recommendations on chloride testing methods, maximum allowable chloride levels, and surface preparation.
J. A paint repair plan for the repair of damaged areas.

The Engineer shall have 14 calendar days to review the PQWP submittal after a complete plan has been received. No painting or paint removal shall be performed until the PQWP for that work is approved by the Engineer.

It is expressly understood that the Engineer's approval of the Contractor's PQWP shall not relieve the Contractor of any responsibility under the contract for the successful completion of the work in conformity with the requirements of the plans and specifications. The Engineer's review shall not constitute a waiver of any of the requirements of the plans and specifications nor relieve the Contractor of any obligation thereunder, and defective work, materials, and equipment may be rejected notwithstanding review of the PQWP.

CLEANING

Exposed new metal surfaces, except where galvanized or metallized, shall be dry blast cleaned in conformance with the requirements in Surface Preparation Specification No. 10, "Near White Blast Cleaning," of "SSPC: The Society for Protective Coatings." Blast cleaning shall leave surfaces with a dense, uniform, sharp angular anchor pattern of not less than 40 µm nor more than 86 µm as measured in conformance with the requirements in ASTM Designation: D 4417.

Mineral and slag abrasives used for blast cleaning steel shall conform to the requirements in Abrasive Specification No. 1, "Mineral and Slag Abrasives," of "SSPC: The Society for Protective Coatings" and shall not contain hazardous material. Mineral and slag abrasives shall comply with the requirements for Class A, Grade 2 to 3 as defined therein.

Steel abrasives used for blast cleaning steel surfaces shall comply with the requirements of SSPC-AB 3, "Newly Manufactured or Re-Manufactured Steel Abrasives" of "SSPC: The Society for Protective Coatings". If steel abrasive is recycled through shop or field abrasive blast cleaning units, the recycled abrasive shall conform to the requirements of SSPC-AB 2 "Specification for Cleanliness of Recycled Ferrous Metallic Abrasives" of "SSPC: The Society for Protective Coatings". The abrasive size and type shall be selected and maintained so as to achieve the required surface profile.

A Certificate of Compliance conforming to the provisions in Section 6-1.07, "Certificates of Compliance," of the Standard Specifications and a Material Safety Data Sheet shall be furnished prior to use for each shipment of blast cleaning material for steel.

The inside surfaces of bolt holes shall be cleaned in conformance with the requirements in Surface Preparation Specification No. 1, "Solvent Cleaning," of the "SSPC: The Society for Protective Coatings," and visible rust shall be removed.

Abrasive blast cleaned surfaces shall be tested by the Contractor for soluble salts in conformance with the requirements in SSPC: The Society for Protective Coatings Technical Update No. 4, “Field Methods for Retrieval and Analysis of Soluble Salts on Substrates” and cleaned, if necessary, so that the maximum level of chlorides does not exceed the lesser of the coating manufacturer’s written recommendations or 10 micrograms per square centimeter. Areas of abrasive blast cleaned steel shall be tested for chlorides at the rate of one test per 200 square meters or part thereof at locations chosen by the Engineer. If chloride levels exceed the maximum allowed by these special provisions, the entire 200 square meter area represented by the testing will be rejected. The Contractor shall perform additional cleaning and testing of rejected areas until chloride levels conform to these requirements.

Chloride testing of abrasive blast cleaned steel may be waived by the Engineer if the steel has not been manufactured, transported or stored in a marine or salt-containing environment. A salt-containing environment includes roads or highways where deicing salts have been used.

MATERIAL ANOMALIES

Corners shall be chamfered to remove sharp edges.

Chamfering is defined as a process by which a sharp corner is flattened by passing a grinder or other suitable device along the corner, normally in a single pass.

Preparation of Thermal Cut Edges – Thermal cut edges (TCEs) to be painted shall be conditioned before blast cleaning,

Edge conditioning is defined as very shallow grinding or other pre-blast cleaning preparation of thermal cut edges (TCEs) to remove a thin, hardened layer left by resolidification.

Base Metal Surface Irregularities –All visually evident surface defects shall be removed in accordance with ASTM A 6 or AASHTO M 160 prior to blast cleaning steel. When material defects exposed by blast cleaning are removed, the blast profile must be restored by either blast cleaning or by using mechanical tools in accordance with SSPC-SP 11.

PAINTING

Blast cleaned surfaces shall receive a single undercoat of inorganic zinc primer and, unless otherwise specified, a single finish coat of an inorganic thermosetting hybrid coating based upon a polysiloxane resin co-reacted or blended with an epoxy, acrylic, or urethane resin or combination thereof supplied by the manufacturer of the inorganic zinc coating.

The single undercoat shall consist of an inorganic zinc coating conforming to the requirements in AASHTO Designation M 300, Type 1- or Type II, except that: 1) the first 3 sentences of Section 5.6, "Primer Field Performance Requirements," shall not apply for Type II coatings and the entire Section 5.6.1 shall not apply for either type of inorganic zinc coating.

If the Contractor proposes a Type 1 coating, the Contractor shall furnish to the Engineer for approval documentation as required in Section 5.6 of AASHTO Designation M300. The Contractor shall allow the Engineer 30 working days to review the proposal.

If the Contractor proposes to use a Type II coating, the coating shall be chosen from the qualified products list, which may be obtained from the Transportation Laboratory.

The inside surfaces of bolt holes shall be maintained free from visible corrosion until final assembly or recleaned prior to assembly so as to remove all visible corrosion. After assembly, the inside surface of bolt holes that are not sealed by bolts or washers shall be painted with two applications of a zinc rich primer (organic vehicle type) after completion of all applications of the undercoat of inorganic zinc on adjacent steel. Application of primer to the inside surfaces of bolt holes will require removal and replacement of the fastener assembly. If rust staining on coated surfaces occurs, all stains shall be completely removed by abrasive blast cleaning and reapplication of primer to specified requirements prior to application of finish coats. Finish coats are not required for the inside surfaces of bolt holes

Inorganic zinc coating shall be used within 12 hours of initial mixing.

Application of inorganic zinc coating shall conform to the provisions for applying zinc-rich coating in Section 59-2.13, "Application of Zinc-Rich Primer," of the Standard Specifications.

Inorganic zinc coating shall not be applied when the atmospheric or surface temperature, or relative humidity does not conform with the manufacturer's published application requirements. The single undercoat of inorganic zinc coating shall be applied to the required dry film thickness in 2 or more applications within 4 hours after blast cleaning. No significant time needs to elapse between the two paint applications. A commonly used procedure to satisfy this requirement is to apply horizontal passes with 50% overlap, followed by vertical passes with 50% overlap.

The total dry film thickness of all applications of the inorganic zinc undercoat, including the surfaces of outside existing members within the grip under bolt heads, nuts and washers, shall be not less than 90 µm nor more than 150 µm, except that the total dry film thickness on each faying (contact) surface of high strength bolted connections shall be between 25 µm and the maximum allowable dry film thickness as determined by certified testing in conformance with Appendix A of the "Specification for Structural Joints Using ASTM A325 or A490 Bolts" of the Research Council on Structural Connections (RCSC Specification). Unless otherwise stated, all coatings used on faying surfaces shall meet the slip coefficient requirements for a Class B coating on blast-cleaned steel, as specified in the RCSC Specification. The Contractor shall provide results of certified testing showing the maximum allowable dry film thickness for the Class B coating from the qualifying tests for the coating he has chosen, and shall maintain the coating thickness on actual faying surfaces of the structure at or below this maximum allowable coating thickness.

Areas where mudcracking occurs in the inorganic zinc coating shall be blast cleaned and repainted with inorganic zinc coating to the specified thickness.

Dry spray, or overspray, as defined in the Steel Structures Painting Manual, Volume 1, "Good Painting Practice," of the "SSPC: The Society for Protective Coatings," shall be removed prior to application of subsequent coats or final acceptance. Removal of dry spray shall be by screening or other methods that minimize polishing of the inorganic zinc surface. The dry film thickness of the coating after removal of dry spray shall be in conformance with the provisions for applying the single undercoat, as specified herein.

The inorganic zinc coating shall be tested for adhesion, hardness and chlorides. All tests shall be done in the presence of the Engineer or his designated representative unless otherwise directed by the Engineer in writing. Additional testing as defined in this section shall also be required for water borne inorganic zinc and solvent borne inorganic zinc coatings. The Engineer will determine the locations of the tests. The Contractor shall determine the sequence of the rinsing and testing operations. At the Contractor's expense, satisfactory access shall be provided to allow the Engineer to determine the location of the tests.

The following tests shall be performed on both water borne inorganic zinc primers and solvent borne inorganic zinc primers:

1. Adhesion

   The inorganic zinc coating shall have a minimum adhesion to steel of 4 MPa. Testing shall be performed at a minimum frequency of 1 test per 100 square meters of painted area using a self-aligning adhesion tester in conformance with the requirements in ASTM Designation: D 4541. The Contractor, at the Contractor's expense, shall: (1) verify compliance with the adhesion requirements, (2) furnish test results to the Engineer, and (3) repair the coating after testing.

2. Chlorides and Water Rinsing

   Except as approved by the Engineer, a minimum time of 72 hours shall be allowed between application of inorganic zinc coating and water rinsing.

   All areas of inorganic zinc coating, where finish coats are specified, shall be water rinsed in conformance with the requirements in Section 59-1.03 “Application,” of the Standard Specifications and these special provisions. Areas of the coating that are removed by the water rinsing shall be reapplied in conformance with the provisions for applying zinc-rich coating in Section 59-2.13, "Application of Zinc-Rich Primer," of the Standard Specifications and these special provisions.

All areas of inorganic zinc coating where finish coats are to be applied shall be tested by the Contractor for soluble salts in conformance with the requirements in SSPC: The Society for Protective Coatings Technical Update No. 4, “Field Methods for Retrieval and Analysis of Soluble Salts on Substrates” and cleaned, if necessary, so that the maximum level of chlorides does not exceed the lesser of the manufacturer’s written recommendations or 10 micrograms per square centimeter. Areas of inorganic zinc coating shall be tested for chlorides at the rate of one test per 200 square meters or part thereof at locations chosen by the Engineer. If chloride levels exceed the maximum allowed by these special provisions, the entire 200 square meter area represented by the testing will be rejected. The Contractor shall perform additional cleaning and testing of rejected areas until chloride levels conform to these requirements.

Finish coat shall be applied to areas passing the chloride tests within 48 hours.

3. Hardness

   Prior to application of finish paint, the inorganic zinc coating shall exhibit a solid, hard, and polished metal surface when firmly scraped with the knurled edge of a quarter. Inorganic zinc coating that is powdery, soft, or does not exhibit a polished metal surface, as determined by the Engineer, shall be repaired by the Contractor, at the Contractor's expense, by blast cleaning and repainting with inorganic zinc coating to the specified thickness.

Additional Requirements for Water Borne Inorganic Zinc Primers

1. Steel painted with water borne inorganic zinc primer shall be protected at all times from water immersion conditions during curing, shipping, and storage until the surface pH, measured as described herein, is less than or equal to 7, and until the coating passes the solvent insolubility test described below. Water immersion conditions are defined as standing water or continuous contact with wet materials for periods in excess of 30 minutes. The Contractor, at the Contractor's expense, shall repair damage caused due to immersion conditions by blast cleaning and repainting with inorganic zinc coating to the specified thickness.

2. The surface pH of the inorganic zinc primer shall be tested by wetting the surface with de-ionized water for a minimum of 15 minutes and no longer than 30 minutes and applying pH paper with a capability of measuring in increments of 0.5 pH units. At least two surface pH readings shall be taken for each 50 square meters or portion thereof. If less than 50 square meters of steel is coated in a single shift or day, at least two surface pH readings shall be taken for primer applied during that period. Application of finish coats will not be permitted until the surface pH is less than or equal to 7.

3. Dry to solvent insolubility for water borne inorganic zinc primers shall be determined in conformance with the requirements in ASTM Designation: D4752, "Standard Test Method for Measuring MEK Resistance of Ethyl Silicate (Inorganic) Zinc-Rich Primers by Solvent Rub” except that water shall be the solvent. The resistance rating shall not be less than 4. Areas of inorganic zinc coating shall be tested for solvent insolubility at the rate of one test per 50 square meters or portion thereof. Inorganic zinc coating that does not meet the solvent insolubility requirement shall be repaired by the Contractor, at the Contractor's expense, by blast cleaning and repainting with inorganic zinc coating to the specified thickness.

Additional Requirements for Solvent Borne Inorganic Zinc Primers

1. Dry to solvent insolubility for solvent borne inorganic zinc primers shall be determined in conformance with the requirements in ASTM Designation: D4752, "Standard Test Method for Measuring MEK Resistance of Ethyl Silicate (Inorganic) Zinc-Rich Primers by Solvent Rub." The resistance rating shall not be less than 4. Areas of inorganic zinc coating shall be tested for solvent insolubility at the rate of one test per 50 square meters or portion thereof. Inorganic zinc coating that fails to meet the solvent insolubility requirement shall be repaired by the Contractor, at the Contractor's expense, by blast cleaning and repainting with inorganic zinc coating to the specified thickness. The Contractor shall maintain suitable enclosures to protect the inorganic zinc coating from damage caused by the environment until the coating passes this test and is fully cured per the manufacturer's written recommendations.

Finish Paint

Except as noted, exterior surfaces of undercoated areas and bolts shall receive a single finish coat of an inorganic thermosetting hybrid coating based upon a polysiloxane resin co-reacted or blended with an epoxy, acrylic, or urethane resin or combination thereof supplied by the manufacturer of the inorganic zinc coating. The coating shall not contain any isocyanate or polyisocyanate components. Exterior surfaces are defined as steel surfaces undercoated with inorganic zinc which are visible in the finished work from the outside of the bridge.

The surface of the undercoat that is to be covered shall be free from moisture, visible dust, visible grease, or other deleterious materials immediately prior to application of finish paint.

Galvanized or metallized surfaces designated to receive finish paint shall be cleaned in accordance with the requirements of SSPC-SP 1 and then primed with a galvanized surface primer recommended by the manufacturer of the polysiloxane finish paint. The complete finish paint system on galvanized fasteners shall have a minimum adhesion of 4 A when measured in accordance with ASTM D 3359.

Finish coats will not be required on exterior surfaces receiving an overlay.

Finish coats are not required on interior surfaces. Interior surfaces are defined as steel surfaces undercoated with inorganic zinc not visible from the outside of the bridge and include, but are not limited to, the inside surfaces of the box girder, crossbeams and tower shafts.

The finish coat shall be field applied within 48 hours following water rinsing and passing the chloride testing as specified previously in this section.

The finish coat paint shall be formulated for application to inorganic zinc coating and shall conform to the following:

Exposure Test	**Exposure Time**	**Measurement Test/** Minimum Criteria	
		Color Retention per ASTM D 2244 **(Color change in ΔE*)**	Maximum Gloss Reduction from Original Reading per ASTM D 523
Accelerated Weathering[c] (ASTM D 4587, Cycle 2)	4,000 hours	<2.0	10%

TEST METHOD		**CRITERIA**
Solvent resistance (ASTM D 5402)	100 double rubs with MEK	No visible topcoat on cloth, No softening (ASTM D 3363)
Adhesion to primed steel (ASTM D 4541, Type III, IV or V)		Minimum 5 Mpa. Adhesion greater than 4 Mpa satisfies this requirement if failure is in primer.
Adhesion to galvanized steel (ASTM D 3359, Procedure A, surface cleaned per SSPC-SP 1 and primed with manufacturer's recommended galvanized surface primer)		Minimum 4 A
Dry-Through (or Dry-To-Handle) Time (ASTM D 1640)		8 hours maximum
Abrasion Resistance (ASTM D 4060), 1000 cycles, CS17 wheel , 1 Kg load		< 0.125 g loss
Mandrel Bend (ASTM D 522, Method B), 125µm dry film applied to abraded steel plate		No cracking on 12.7 mm mandrel
Water Resistance (ASTM D 870), 125µm dry film on primed steel, cured 7-days.		No change in color or gloss after 7-days. Adhesion greater than 4 Mpa after 48-hours recovery

The finish coat shall be applied in 2 applications. The first application shall consist of a spray applied mist application. The second application shall be applied after the mist application has dried to a set to touch condition as determined by the procedure described in Section 7 of ASTM Designation: D1640. The finish coat color shall match Federal Standard 595B No. 26408. The total dry film thickness of both applications of the finish coat shall be not less than 125 µm.

The total dry film thickness of all applications of inorganic zinc coating and finish coat paint shall be not less than 200 µm nor more than 325 µm.

PAYMENT

Payment for clean and paint structural steel shall conform to the provisions in Section 59-2.16, "Payment," of the Standard Specifications and these special provisions.

Cleaning and painting structural steel, of the types listed in the Engineer's Estimate, will be paid for on the basis of lump sum price.

Full compensation for water rinsing and conforming to the requirements for testing outlined in these special provisions, including providing access for testing and repairing painted surfaces, and for services of the manufacturer's technical representative shall be considered as included in the contract lump sum price paid for clean and paint structural steel of the types listed in the Engineer's Estimate and no additional compensation will be allowed therefor.

10-1.64 CLEAN AND PAINT CABLE SYSTEM

This work shall consist of surface preparation and painting of the cable system as shown on the plans, in accordance with the provisions in Section 59, "Painting," of the Standard Specifications and these special provisions.

A qualified representative of the manufacturer shall be present for the test demonstration, and for at least 3 days at the beginning of the application and at completion of the application. The manufacturer's representative shall certify to the Engineer in writing that the proper installation procedures are being followed, including, but not limited to the following:

A. Surface preparation.
B. Type of equipment used.
C. Mixing of the material components.
D. Method of application, and finish.

Handling, mixing and addition of thinners or any other material shall be performed in accordance with the manufacturer's recommendations and with prior approval of the Engineer.

The cable paint system shall not be applied when weather or surface conditions, as determined by the Engineer, are such that the material cannot be properly handled, applied, and cured within the specified time.

The Contractor shall perform a test demonstration, in the presence of the Engineer and the manufacturer's representative, of all cable paint system application procedures to be used. The test demonstration shall consist of surface application and painting of two adjacent cable bands and the main cable between them. The Contractor shall notify the Engineer at least 20 working days prior to the test demonstration.

MATERIALS

The cable painting system shall consist of a primer, a two intermediate coat Noxyde painting system, or equal, and a finish coat. The Noxyde cable painting system shall be manufactured by the following supplier:"

VENDOR ADDRESS AND PHONE NUMBER
MARTIN MATHYS S.A. KOLENBERG 23 3545 ZELEM/HALEN BELGIUM

The primer shall be a waterborne, single component acrylic coating with highly elastic polymers that cure to a highly elastic, seamless rubber coating. The primer shall be Pegalink or equal.

The two intermediate coats shall be 100 percent Noxyde Plus.

The finish coat shall be a water-borne, single component semi-gloss acrylic paint. The finish coat shall be Pegacryl or equal.

The primer, intermediate coats, and finish coat shall be 3 different colors. The finish coat color shall match Federal Standard 595B, No. 26408. Color samples shall be submitted to the Engineer for approval 2 months prior to the start of painting.

Each shipment of cable paint system materials shall be accompanied by a Certificate of Compliance as provided in Section 6-l.07, "Certificates of Compliance," of the Standard Specifications. The certificate shall state that the materials and fabrication involved comply in all respects to the specifications and data submitted in obtaining approval, and shall include the type of paint products used and the application rates of all components of the cable paint system. The first shipment shall include a copy of the manufacturer's quality assurance program listing all in-house testing criteria.

Copies of Material Safety Data Sheets (MSDS) for all materials shall be kept on site for review by the Engineer.
The Contractor shall be responsible for the workmanship and performance of the installed cable paint system.
The cable paint system shall be applied by a manufacturer certified applicator.
The primer for the cable paint system shall conform to the following physical requirements:

Property	Test	Requirement
Weight of Solids	ASTM Designation: D2369	48% ± 2%
Specific Gravity		1.2± 0.03
Volume of Solids	ASTM Designation: D2697	45.4% ± 2%
Elasticity		200% Elongation
Water Resistance		100%
Alkali Resistance		Fair
Salt Spray Resistance		100%
Water Vapor Transmission	ASTM Designation: E96	15g H2O/m2 in 24 hours
Chemical Resistance	10% Acid solution	Fair

The intermediate coats of the cable paint system shall conform to the following physical requirements:

Property	Test	Requirement
Weight of Solids	ASTM Designation: D2369	67% ± 2%
Specific Gravity		1.26± 0.02
Volume of Solids	ASTM Designation: D2697	57% ± 2%
Elasticity	CSTB No. 15.381	200% Elongation
Water Resistance		12 mo. Immersion, no change
Alkali Resistance		No damage from Na(OH) at pH = 14
Salt Spray Resistance	CSTB No. 15.381	100%
Water Vapor Transmission	ASTM Designation: E96	5.5g H2O/m2 in 24 hours
Chemical Resistance	25% mineral acid solution	Excellent
UV Ray Resistance		100% against outdoor exposure
Shore A Hardness		70
Aging and Adhesion		Unaffected after 8 hours, 60°C to -20°C with rain, frost, UV light and humidity
Sulfur Dioxide Resistance		100% resistance
Ozone Resistance		No cracking or embrittlement when subjected to 1 PPM ozone for 30 days
Hot water immersion		No effect after 1000 hours in 38°C water
Impact Resistance	DIN 51155	90 N
Tensile Adhesion	CSTB (France)	47.5 An/cm2
Sand Blasting Resistance	DIN 51155	Unaffected at 20,000 shots

A minimum of four ounces of polyolefin beads conforming to the properties in the following table shall be added to each gallon of finish paint applied to horizontal or walking surfaces. The beads shall be added to the paint prior to application and be thoroughly dispersed into the coating during normal mixing procedures. The cured coating, following addition of polyolefin beads, shall have a minimum average slip-resistance of 0.50 when wet as determined in accordance with ASTM Designation F 1679. Additional beads shall be added if the average slip-resistance fails to meet this requirement as determined by the Contractor's independent laboratory upon testing of a sample of the finish paint. A copy of the slip-resistance testing results shall be furnished to the Engineer prior to application of finish paint.

Property	Requirements
Composition	Polyethylene or Polypropylene or a combination thereof
Appearance	White free-flowing powder
Size	210 to 300 µm
Specific Gravity	0.90
Initial Melt/Softening point	-6°C
Final Melt Point	166°C
Flash Point	greater than 275°C

The Contractor shall verify by testing that all properties are met. The physical properties shall be verified by an independent laboratory approved by the Engineer.

All material components of the cable paint system shall be supplied to the job site in the manufacturer's unopened packaging. Material for the cable paint system in opened or damaged containers shall not be used and shall be removed from the job site at the Contractor's expense.

All material components of the cable paint system shall be stored in cool, dry conditions, between 5°C and 20°C, out of direct sunlight and in accordance with the manufacturer's recommendations and Health and Safety regulations.

CLEANING

The main cables, suspender ropes, and handropes shall be cleaned in accordance with the provisions of Surface Preparation Specification No. 1, "Solvent Cleaning," of the SSPC: The Society for Protective Coatings. All traces of the zinc waterproofing paste applied to the main cable wires which has bled through the exterior wire wrapping shall be removed. Solvent cleaning shall be supplemented by hand tool cleaning in accordance with the provisions of Surface Preparation Specification No. 2, "Wire Brushing, and Hand Washing, and Rinsing," of the SSPC: The Society for Protective Coatings to remove any non-adherent shop applied coating, or detrimental foreign matter unable to be removed by solvent cleaning. Brass wire brushes shall be used for this surface preparation. Steel wire brushes will not be permitted.

Handrope stanchions, main cable shrouds, and the surfaces of cable band castings, tower saddle castings, deviation saddle castings, jacking saddle castings and splay saddle castings which are not in contact with the main cable shall be dry blast cleaned in accordance with the provisions of Surface Preparation Specification No. 10, "Near White Blast Cleaning," of the SSPC: The Society for Protective Coatings. Blast cleaning shall leave all surfaces with a dense, uniform, angular, anchor pattern of no less than 40 µm as measured in accordance with the requirements of ASTM Designation: D 4417.

All steel surfaces to be coated with the Noxyde paint system shall be cleaned to remove all oil, dirt, rubber, dust, and other material which would prevent proper bonding to and curing of the primer.

After wrapping of the main cable and prior to application of the prime coat, the main cable shall be securely wrapped with a waterproof film to protect from salt air. The waterproof film shall not be removed sooner than 72 hours prior to application of the prime coat. Solvent and hand cleaning, as described in this section, will not be permitted as a substitute for placement of waterproof film.

Immediately prior to the application of any component of the Noxyde system, the receiving surface shall be dry and all remaining dust or loose particles shall be removed by blowing with clean, dry, oil free air.

PAINTING

Primer shall be applied within 4 hours of the completion of surface preparation. All locations showing evidence of contamination, as determined by the Engineer, shall be recleaned at the Contractor's expense. The Engineer shall be the sole judge of the need for recleaning.

Primer shall be applied in accordance with the manufacturer's recommendations. The primer shall be spray applied in a fine even spray so as to produce a uniform coating. The dry film thickness of the primer shall be 35 µm.

Primer shall be applied to the handrope stanchions, main cable shrouds, and the surfaces of cable band castings, tower saddle castings, and splay saddle castings which are not in contact with the main cable.

Surfaces painted with primer shall be protected from damage. Should damage to the primer occur, as determined by the Engineer, the surface shall be repaired at the Contractor's expense prior to application of the intermediate coat.

The primer shall cure before application of the intermediate coat. The Engineer with the assistance of the manufacturer's representative at the job site shall determine when the cure is adequate to continue.

The intermediate coat shall be applied within 24 hours of the application of primer coat, weather permitting, except for the handrope stanchions, main cable shrouds, and the surfaces of cable band castings, tower saddle castings, and splay saddle castings. All undercoat surfaces showing evidence of contamination, as determined by the Engineer, shall be cleaned. The Engineer shall be the sole judge of the need for cleaning.

The intermediate coat shall be applied in accordance with the manufacturer's recommendations. The two intermediate coats shall be spray applied in a fine even spray so as to produce a uniform coating. The total dry film thickness of the two intermediate coats shall be between 200 µm and 350 µm."

The intermediate coat shall cure before application of the finish coat. The Engineer with the assistance of the manufacturer's representative at the job site shall determine when the cure is adequate to continue.

The finish coat shall be applied within 24 hours of the application of intermediate coat, weather permitting. All locations showing evidence of contamination, as determined by the Engineer, shall be cleaned in accordance with the manufacturer's recommendations.

The application of the intermediate coat and the finish coat shall not be made if rain is forecast within 6 hours of application, or as determined by the Engineer. The finish coat shall be applied only when the atmospheric and steel temperatures are above 10°C and the relative humidity is below 85 percent, and these conditions are forecast to be maintained for a minimum of 6 hours. The temperature of the main cable shall be at least 3˚C above the dew point.

The finish coat shall be applied in accordance with the manufacturer's recommendations. The finish coat shall be applied to produce a uniform coating. The dry film thickness of the finish coat shall be 35 µm."

The total dry film thickness of all three coats shall be between 270 µm and 420 µm. The color of each coat shall be uniform throughout the entire member.

The Contractor shall check wet film thickness at least once every 10 square meters using a gauge pin or standard comb type thickness gauge.

The painted surface shall be checked for visible pinholes and other surface defects. The paint system shall provide a smooth, pinhole free continuous film on all coated surfaces.

In the event that any materials are damaged during this work due to the Contractor's operations, the Contractor shall repair or replace the damaged materials at the Contractor's expense, and as approved by the Engineer.

MEASUREMENT AND PAYMENT

Clean and paint cable system will be measured and paid for on a lump sum basis.

The contract lump sum price paid for clean and paint cable system shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, including the services of the manufacturer's representative as specified herein, and for doing all the work involved in clean and paint cable system, as shown on the plans, as specified in the Standard Specifications and these special provisions, and as directed by the Engineer.

10-3.16 SUPERVISORY CONTROL AND DATA ACQUISTION REMOTE TERMINAL UNIT SYSTEM

GENERAL

Attention is directed to "Order of Work" of these special provisions for the timely identification of the supplier of the remote terminal units and products to be used by the Contractor.

The State will arrange for the procurement and installation of a new SCADA Master Programmable Logic Controller (PLC) including workstations. The equipment will be installed in the Administration Building. The communications protocol between field devices and the RTUs will be MODBUS. Communications between the RTUs and the SCADA Master Controller (HMI) shall be through the use of frequency shift key (FSK) modem

The Contractor shall arrange for the procurement and installation of the SCADA remote terminal units (RTUs) with the Engineer prior to procurement and shall provide identical equipment as used in Contract No. 04-012024, constructing San Francisco-Oakland Bay Bridge structures, to assure compatibility between the SCADA RTUs and the new SCADA Master PLC.

The Contractor shall arrange for the RTU supplier to generate complete wiring diagrams, based on shop drawings, of each RTU, showing all incoming cable and wire terminations to be terminated by the Contractors. The wire, cable and circuit numbers shall match and be coordinated with the RTU requirement plans (elementary and wiring diagrams), furnished for the SCADA RTU system. This information shall be available for the Engineer to review upon request prior to installing any of the RTUs.

SUBMITTALS

Each submittal package shall consist of six copies. Submittals shall be delivered to the Engineer at least 180 days prior to the start of the installation. The Engineer will be allowed 90 days for review of the submittals.

Submittals (For Review and Approval)

The following information shall be submitted to the Engineer:

A. Master drawing index
B. Front view elevation
C. Floor plan
D. Top view
E. Block diagram
F. Schematic diagram
G. Nameplate schedule
H. Component list
I. Conduit entry and exit locations
J. Assembly ratings including:

    1. Voltage
    2. Continuous current

K. Cable terminal sizes

Key interlock schematic plans and sequence of operations shall be submitted to the Engineer:

Submittals (For Information)

When requested by the Engineer the following product information shall be submitted:

A. Descriptive bulletins
B. Product data sheets.

Submittals (For Final Acceptance)

The following information shall be submitted for record purposes prior to final payment:

A. Final as-built plans drawings and information for remote terminal units.
B. Wiring diagrams
C. Certified production test reports
D. Installation information
E. Seismic certification and equipment anchorage details.

Operation and Maintenance Manuals

Ten (10) copies of the equipment operation and maintenance manuals shall be provided prior to shipment of the equipment.

Operation and maintenance manuals shall include the following information:

A. Instruction books or leaflets
B. Recommended renewal parts list

PROGRAMMABLE CONTROLLER

Scope

This section covers the technical requirement for a programmable controller which can receive discrete and analog inputs. Through the use of relay ladder logic and other languages, including "C", State Logic and Sequential Function Chart (SFC), it can control discrete and analog output functions, perform data handling operations and communicate with external devices.

Manufacturer's Standards

The manufacturer shall have shown high commitment to product, manufacturing and design process quality. It shall have attained ISO9001 registration.

Design and Manufacturer

The SCADA RTUs furnished by the contractor, will be part of the overall new San Francisco – Oakland Bay Bridge SCADA system, to be furnished and installed by multiple contractors. The Contractor shall ensure compatibility with the overall SCADA system by providing identical equipment as used in Contract 04-012024. The new RTUs for the San Francisco – Oakland Bay Bridge shall be furnished with GE 90-30 PLCs or equal. The RTU cabinets, including all internal subcomponents, shall, where applicable, be identical to the subcomponents furnished with the RTUs as used in Contract 04-012024.

The SCADA RTU system shall be obtained from the following supplier:

VENDOR ADDRESS AND PHONE NUMBER
INKELIS ASSOCIATES 6722 CORTE SANTA MARIA PLEASANTON, CA 94566 TEL: 925-485-0794 FAX: 925-485-0794 CONTACT: KAREN INKELIS

The unit prices quoted by the supplier for the SCADA RTU system are as follows:

	QTY	NTP 2004	NTP 2005	NTP 2006	NTP 2007	NTP 2008
RTU-10W & 10E	2	$69,000	$72,588	$78,674	$84,008	$85,703
RTU-11W & 11E	2	$67,000	$70,484	$76,393	$81,573	$87,103
#COM-4 Terminal Cabinet	1	$ 3,850	$ 4,050	$ 4,390	$ 4,687	$ 5,005
#COM-5,6,7,8 Terminal Cabinets	4	$ 3,875	$ 4,077	$ 4,428	$ 4,718	$ 5,038
#TEL-4,5,6,7,8 Terminal Cabinets	5	$ 4,050	$ 4,261	$ 2,618	$ 4,931	$ 5,265
Testing and Checkout (hr)	64	$ 7,900	$ 8,311	$ 9,008	$ 9,618	$10,274
Training (hr)	12	$ 3,000	$ 3,156	$ 3,421	$ 3,653	$ 3,900
Software Programmer (hr)	24	$ 4,200	$ 4,418	$ 4,789	$ 5,114	$ 5,460
Relay	24	$ 720	$ 757	$ 821	$ 877	$ 936

The prices quoted are effective for each NTP (Notice to Proceed) yearly period from January 19 to January 18 of the following year. The FOB location is Everett, Washington. The above prices include freight and insurance, but do not include sales tax. All products are tested and ETL Labeled before shipment.

The programmable controller and all of the corresponding components within the family of controller products shall be offered by a company who regularly manufactures and services this type of equipment**.**

All products shall be designed, manufactured, and tested in accordance with recognized UL, CSA, IEC and CE mark industrial standards. The system shall be operational during and after testing. The standards requirements are as follows:

The programmable controller and all of the corresponding components within the family of controller products shall be offered by a company who regularly manufactures and services this type of equipment**.**

All products shall be designed, manufactured, and tested in accordance with recognized UL, CSA, IEC and CE mark industrial standards. The system shall be operational during and after testing. The standards requirements are as follows:

AGENCY APPROVALS OVERVIEW		*Comments*
Quality Assurance in Design/ Development, Production, Installation & Servicing	**ISO9001**	Certification by Underwriters Laboratories and BSI Quality Assurance
Safety for Industrial Control Equipment	**UL508** **C-UL or CSA 22.2, 142-M1987**	Certification by Underwriters Laboratories Certification by Underwriters Laboratories [C-UL] or Canadian Standards Association for selected modules
Safety for Hazardous Locations Class I, Div II, A, B, C, D	**UL1604 with C-UL** **FM3611** **CSA22.2, 213-M1987**	Certification by Underwriters Laboratory for selected modules Certification by Factory Mutual for selected modules Certification by Canadian Standards Assocation for selected modules
European EMC and Low Voltage Directives	**CE Mark**	Certification by Competent Body for EMC Directive for selected modules

STANDARDS OVERVIEW		*Conditions*
ENVIRONMENTAL		
Vibration	**IEC68-2-6, JISC0911**	IG@40-150Hz, 0.012in p-p@10-40Hz
Shock	**IEC68-2-27, JISC0912**	15G.11ms
Operating Temperature		0°C to 60°C:[inlet] 0°C to 55°C:[ambient]
Storage Temperature		-40°C to +85°C
Humidity		5% to 95%, non-condensing
Enclosure Protection	**IEC529**	Steel cabinet per IP54: protection from dust & splashing water
EMC EMISSIONS		
Radiated Conducted	**CISPR11, EN55011 FCC**	Class A [applies to CE Marked modules] part 15, subpart J, Class A
EMC IMMUNITY		**[applies to CE Market modules]**
Electrostatic Discharge	**IEC 1000-4-2**	8KVAir, 4KV Contact
RF Susceptibility	**IEC 1000-4-3**	$10V_{rms}$/m80Mhz to 1000Mhz, 80% AM
Fast Transient Burst	**IEC 1000-4-4**	2KV:power supplies,1KV:I/O,communications
Surge Withstand	**ANSI/IEEE C37.90a IEC255-4**	Ring Wave, 2.5KV: Power supplies, I/O [12,240V] Ring Wave, Class II: Power supplies, I/O[12,240V]
Conducted RF	**IEC 1000-4-6**	$10V_{rms}$, 150khz to 80Mhz, 80%AM: communication modules with cables>30m
ISOLATION		
Dielectric Withstand	**UL508, UL840, IEC664**	1.5KV for modules rated from 51v to 250v
POWER SUPPLY		
Input Dips, Variations	**IEC 1000-4-11**	During Operation: Dips to 30% and 100%, Variation for AC +/- 10%, Variation for DC +/- 20%

The manufacturer shall have a fully operational quality assurance and quality control program in place and shall comply with ISO9001 standards for "Quality Systems- Model for Quality Assurance in Design/Development, Production, Installation, and Servicing."

Complete documentation describing installation, operation, programming and simple field maintenance shall be available in paper format and on CD-ROM.

Support

The manufacturer or its authorized representative shall provide complete technical support for all of the products. This shall include headquarters or local training, regional application centers, and local or headquarters technical assistance. A toll-free (800) number hot-line shall be available for emergency support.

Product shall have a warranty period of at least 1 year from the date of purchase. The contractor shall maintain the warranties of the product to the completion of the project.

Hardware

The system shall consist of rugged components designed specifically for industrial environments. A complete system shall consist of one or more racks containing I/O modules, interconnected by signal cables.

Packaging

All components shall be housed in structurally secure enclosures.

The controller CPU shall be modular. The modular type shall be fully enclosed within a durable plastic shroud. When mounted on the system base, the modular CPU shall not occupy more than one available slot.

The I/O system shall be modular. Each module shall be fully enclosed within a durable plastic shroud. When mounted on the system base, each I/O module shall not occupy more than one available slot.

There shall be at least two sizes of I/O bases available. One shall hold up to 10 I/O modules and the other shall hold up to 5 I/O modules.

I/O modules shall be retained in their slot by a hinge on the upper rear edge and snap on the lower rear edge of the baseplate. Removing the module shall require no tools.

I/O modules shall be installed in any available slot in the CPU or expansion baseplates, and shall require no tools for insertion and extraction.

I/O modules shall connect electrically to the baseplate via a pin and socket connector.

I/O modules shall be fully enclosed in a plastic covering protecting the electronic circuitry from exposure.

Durability

All components within the controller family shall be manufactured with a high degree of durability.

All switches and other operator-controlled devices shall be of the size and durability for the intended use as is normally offered for industrial applications.

All signal cables furnished by the manufacturer shall be constructed so as to withstand, without damage, all normal use and handling.

Parts Interchange

In order to minimize spare parts stocking requirements, the controller family shall have a high degree of interchange capability. The power supply, and the battery, and should all operate equally well regardless of the CPU being used.

The system shall incorporate a modular design using plug-in assemblies with pin and socket connectors.

Wherever possible, all assemblies and sub-assemblies performing similar functions shall be interchangeable.

The system design shall accommodate the replacement of assemblies without having to disconnect field wiring. Wherever possible, removable connectors shall be used to connect field wiring to the individual circuit board assemblies.

All major assemblies and sub-assemblies, circuit boards, and devices shall be identified using permanent labels or markings each of which indicates the manufacturer's catalog number, product manufacturing date code, UL and CSA certifications.

Environmental Conditions

All components of the controller system, except CRT terminals and programming workstations, shall meet the following environmental specifications:

STORAGE CONDITIONS: TEMPERATURE -40 to 85 degrees Celsius
OPERATING CONDITIONS: TEMPERATURE 0 to 60 degrees Celsius
HUMIDITY: 5 to 95% relative humidity, non-condensing

Power Supply Module

The power supply shall be a wide range supply operating from a voltage source in the range of 120 to 264 VAC and 90 to 125 VDC, providing 30 Watts of power. Available power shall be 30 Watts at a +5VDC output, 15 Watts at a 24VDC relay power output, and 20 Watts at an isolated 24 VDC output.

Specifications

The power supply shall contain an isolated, internal 24VDC power source for I/O modules requiring 24 V DC power

The power supply shall contain a built-in serial communication port which can be used to:

A. Connect the programmer for PC compatible programming software.
B. Connect to one of the wide variety of third-party operator interfaces utilizing an open architecture software protocol.

This serial port shall provide RS-422 signals with RS-485 compatibility. The characteristics of this port shall be software configurable and shall be modem compatible.

The power supply shall contain dual battery connectors in a battery compartment such that a battery may be installed to protect programming CMOS RAM memory. Dual connectors are required to provide bumpless battery power transfer.

The backup battery for RAM memory shall be a Lithium, long-life battery with a typical life of 6 months under load, and 8 to 10 years under no load. This battery shall be replaceable while power is applied to the PLC.

The power supply shall be modular in design, separate from the CPU and baseplate for easy replacement in the unlikely event of failure.

The power supply shall be universal in design, compatible with main CPU racks, as well as with expansion racks.

There shall also be a super capacitor that provides a minimum of 1 hour batteryless backup power for CPU RAM memory.

Central Processing Unit (CPU)

The CPU shall be a modular CPU with up to 5 different configurations. The CPU shall possess the capability to solve application logic, store the application program, store numerical values related to the application processes and logic, and interface to the I/O systems. The CPU shall need no additional modules to provide at least the following advanced programming features: PID, Modulo, Math, Double Precision math, Logical functions, Subroutines, Data Array Move and Indirect Addressing.

Modular CPU

The modular CPU shall contain a minimum of an Intel 80386EX microprocessor operating at speeds no less than 25 MHz as the main processing element, memory mounted on the board, and a dedicated VLSI Instruction Sequencer Coprocessor (ISCP - Boolean Coprocessor) for performing Boolean operations, and interfaces to a serial port and the system bus.

The modular CPU shall contain a real-time calendar and clock that can be accessed by the user program. This Time of Day clock and calendar shall be battery-backed and maintain seven time functions: Year (2 digits), Month, Day of Month, Hour, Minute, Second, and Day of week.

The modular CPU shall execute Boolean functions at a rate of .22 microseconds per instruction or lower.

The modular CPU shall be capable of controlling up to 79 I/O slots.

The modular CPU shall be able to provide special functions such as High Speed Counter function, Axis Positioning function, and Local Area Networking function.

The modular CPU shall be have 2 additional serial ports, 1 a phone jack RS232 and 1 a 15 pin RS485 for communications. The modular CPU shall also be configured as a Modbus RTU Slave ports, allowing them to communicate with other devices in a communication scheme that allows the PLC to be interrogated by those devices for data. The serial ports shall be supported by an additional Hitachi H8 microprocessor.

Visual Diagnostics

Status of low or dead battery shall be indicated by a red Battery LED on the power supply module.

The diagnostic status of the fuses, for those discrete I/O modules containing fuses, shall be indicated by a red LED mounted on the top of the module. The red LED shall illuminate when a blown fuse condition is present.

Alarm Processor

The modular CPU's shall contain an alarm processor that has special PLC feature designed to receive and process faults. The diagnostics shall provide information on the configuration and CPU, memory, communications and I/O status.

The alarm processor function shall log I/O and system faults in two fault tables that shall be accessible for display on the PC compatible programming software screen or uploaded to a host computer or other coprocessor.

The alarm processor shall maintain the states of up to 128 discrete system diagnostic bits to be read by a host or incorporated as contacts into the ladder program for customized diagnostic routines.

Each fault table shall have a total capacity of 32 faults. The last 16 entries shall maintain the latest 16 faults. The first 16 shall be kept unchanged.

Faults may be cleared by the user by way of a programmer. Provision shall be made by way of passwords to protect these faults from unauthorized clearing.

Alarm Features

The alarm processor shall report three types of fault action; fatal, diagnostic, or informational, and the CPU shall respond as follows:

Fault Action	**Fatal**	**Diagnostic**	**Informative**
CPU Enters STOP Mode	YES	NO	NO
Set Diagnostic Bit	YES	YES	NO
Logged In Fault Table	YES	YES	YES

When an I/O fault occurs, the alarm processor shall report the rack and slot location of the fault, the condition, the address and the circuit number if appropriate.

The modular CPU alarm processor function shall have the capability to time-stamp system faults for future references.

PLC Memory Protection

The PLC shall have 4 levels of security or password privilege levels to prevent unauthorized changes to the contents of the PLC. These built-in privilege levels shall be set in the programming software or with the Hand-Held Programmer and shall impose the following constraints:

Level	Constraint
1.	Read PLC data only (except passwords)
2.	Write to any data memory
3.	#2 and write to all configuration or logic in STOP mode
4.	#3 and write to logic in STOP or RUN mode (on-line change) and password level access.

There shall be one password, one to four ASCII characters in length, for each privilege level in the PLC, and the same password can be used for more than one level.

Any attempts to access or modify information in the PLC without the proper password privilege level shall be denied.

Subroutine Password

The PLC shall have a software OEM key that allows users to control access to each subroutine in the relay ladder program.

OEM Program Protection

The PLC shall have a software OEM key that allows users to protect the resident program from unauthorized reads and writes.

CPU Memory

The PLCs modular CPU shall contains at least the following:

A. 120K 16-bit words for application programming and register, analog input and analog output memory.
B. Up to 16384 (16K) 16-bit registers for data usage.
C. 1280 global references
D. 4096 (4K) internal relay coils
E. 2048 (2K) bits for discrete inputs
F. 2048 (2K) bits for discrete outputs
G. Up to 16384 (16K) 16-bit registers for analog inputs
H. Up to 16384 (16K) 16-bit registers for analog outputs

All application memory shall be available to the user program. Executive level operations performed by the CPU shall not consume application memory.

Memory Storage

The register values and the application program shall be stored in battery backed, CMOS static RAM memory. The application program and system configuration shall also be stored in FLASH memory.

There shall be a long-life Lithium battery used to maintain the contents of the CMOS RAM memory in the CPU.

There shall be an easily accessible battery compartment in the power supply with dual battery connectors. The battery shall be replaceable with power applied to the PLC and without removing the CPU.

An LED shall provide visual indication of the battery condition. Additionally, a low battery condition shall be alarmed with a system diagnostic bit.

The modular CPU shall allow the resident user program to be maintained in the CPU without power applied. Two levels of maintainability shall be provided, short duration and long duration.

For short duration, the program shall be maintained by a hi-capacity capacitor for a period of no less than 1 hour. This allows adequate time for replacing the battery in the power supply module, should the external supply to the CPU be interrupted.

For long duration, the CPU module shall maintain its contents by using the battery. This allows the CPU module to be shipped via surface mail where power supply to the module is not available. This method may be achieved by providing internally mounted battery.

The CPU shall calculate the application program checksum at the end of every sweep. A complete checksum calculation for a program may take several sweeps. A fixed number of program memory checksum shall be calculated each sweep. This number is configurable by the user. If the calculated checksum does not equal the reference checksum, a fault shall be recorded, and the CPU mode will change to STOP.

Programming Devices

A Software programming package, for development of application programs, shall be furnished. The software programming package shall be capable of running on a PC compatible laptop or desktop computer.

On-line and off-line, CPU and I/O configuration and application program development shall be achieved with a PC compatible computer and programming and documentation software. The PC compatible computer shall be connectable to the PLC via a built-in serial communication port on the power supply or serial ports on the CPU. The serial communication port shall provide RS-422 signals with RS-485 compatibility.

In addition to the serial communications, the PC compatible computer shall be connectable to the PLC via Ethernet TCPIP supporting the SRTP application protocol. A separate module providing Ethernet communications through an AAUI connection shall plug into any system.

The programming devices shall have access to the application program, the CPU and I/O system configurations, all registers, CPU and I/O status, system diagnostic relays, and I/O over-ride capabilities.

MS-DOS®/Windows® Compatible Software

The MS-DOS/WINDOWS compatible software shall provide the capability of reading, writing, and verifying the configuration and program with a diskette backup.

The software shall execute on DOS operating system or in a DOS Window in a WINDOWS operating system.

The software shall provide on-screen help information throughout its execution paths.

It shall have the capability of programming the relay ladder program, store the program to the PLC, monitor program and reference address status while the PLC is in Run or Stop mode.

The software must be capable of generating a printout of the program for documentation purposes. The user shall be able to select any of the program documentation below:

Types of Documentation	Description
Print Program	This printout shall print the program logic with or without the equivalent Boolean instructions for each rung, the reference list, reference descriptions and/or users rung comments.
Cross reference tables	This printout shall show the use of references in the program.
Reference tables	This printout shall show the values of each reference in each selected table.
Configuration Printout	This printout shall allow the user to generate a rack hardware and its assigned reference addresses listing, and the CPU configuration listing.

The software shall provide the capability for programming using user-defined variables (nicknames).

The software shall have built-in modem connection capabilities.

WINDOWS® Compatible Software

The WINDOWS compatible software shall provide the capability of reading, writing, and verifying the configuration and program with a diskette backup.

The software shall execute on a Windows® 95 or Windows NT® platform.

The software shall provide on-screen help information throughout its execution paths.

It shall have the capability of programming the relay ladder program, store the program to the PLC, monitor program and reference address status while the PLC is in Run or Stop mode.

The programming software shall support bumpless run mode storage of the program to the CPU.

The software must be capable of generating a printout of the relay ladder program for documentation purposes. The user shall be able to select any of the program documentation below:

Types of Documentation	Description
Print Program	This printout shall print the program logic with or without the equivalent Boolean instructions for each rung, the reference list, reference descriptions and/or users rung comments.
Cross reference tables	This printout shall show the use of references in the program.
Reference tables	This printout shall show the values of each reference in each selected table.
Configuration Printout	This printout shall allow the user to generate a rack hardware and its assigned reference addresses listing, and the CPU configuration listing.

The software shall provide the capability for programming using user-defined variables (nicknames).

The software shall have built-in modem connection capabilities.

The software shall be IEC 1131 compliant.

The software shall have provisions for importing and exporting tag names, comments and descriptions in an .xls format.

Operator Interface

The programming port and its protocol shall be open in architecture. The protocols of this communication port shall be published such that a user may develop their own operator interface device, software or hardware, to access Register, I/O status, I/O override and system diagnostic memory data.

Through an open nature of this communications protocol, a wide variety of operator interface shall be made available. These may be manufacturer's own brand or they may be manufactured by 3rd party vendors.

Programming Language

The CPU shall be capable of solving an application program whose source format shall be relay ladder diagram. The language shall support relay, timers and counters, arithmetic, relational, bit operation, data move, conversion, and control functions.

The CPU shall be capable of solving an application program whose main program format is in Sequential Function Chart (SFC) with underlying code in relay ladder diagram.

Relay Functions

Relay ladder operations shall consist of the following contacts and coils:

Relay Functions

Normally Open Contact
Normally Closed Contact
Coil
Negated Coil
Retentive Coil
Negated Retentive Coil
Positive Transition Coil
Negative Transition Coil
Set Coil (Latch)
Reset Coil (Unlatch)
Retentive Set Coil
Retentive Reset Coil

Positive transition coils and negative transition coils shall function as leading and trailing edge one-shot coils respectively.

Contacts may be referenced any number of times within the application program.

A single rung may contain more than one coil.

There shall be a service that allows user programs to be checked for multiple coil use. This flag may be set to:

Disallow more than one coil in a single rung
Allow multiple coil use but generate warning messages
Allow multiple coil use without warnings

Timers And Counters

Timer and counter operations shall consist of the following types:

Timers And Counter Functions

Retentive On-Delay Timer (ONDTR)
Simple Off- Delay Timer (OFDT)
Simple On-Delay Timer (TMR)
Up Counter (UPCTR)
Down Counter (DNCTR)

The retentive on-delay timer shall behave as a stop-watch that increments time when enabled and holds the current timed value until receiving power flow to the reset input.

The simple on-delay timer shall increment while it receives power flow and reset to zero when power flow stops.

The simple off-delay timer shall increment while it power flow stops and reset to zero when power flow is present.

There shall be at least 682 programmed timers and/or counters available for use in application programs.

Each timer or counter requires the use of three 16-bit registers within %R memory for storage of the preset, the current value and a control word. These three registers shall be accessible to the user via a register reference.

The timers and counters shall not require an output reference. The output of a timer or counter can be used to energize a coil, or enable another function, such as a math function, or another timer or counter.

The time/count limit shall be either a programmed constant or shall be programmable via a register reference value.

The time shall be counted in tenths of seconds or hundredths of seconds, and the range for the timers and counters is 0 to 32,767 time units.

Arithmetic

The arithmetic operations shall support two data types, Signed Integer (INT), and Double Precision Integer (DINT). On the modular CPU, the Floating Point data type shall also be supported via floating point emulation. Arithmetic functions shall consist of the following types:

Arithmetic Functions

Addition
Subtraction
Multiplication
Division (quotient)
Modulo (remainder)

Square Root

Signed Integers (INT) data shall be stored in 16 contiguous bits of memory, in 2's complement notation. The range for Signed Integer Data shall be -32,768 to +32,767.

Double Precision Integer (DINT) data shall be stored in 32 contiguous bits of memory, double precision data is always signed. The range for Double Precision Integer Data shall be -2,147,483,648 to 2,147,483,647.

The arithmetic function blocks shall consist of 3 inputs and 2 outputs. The enable input shall begin the execution. When the function is enabled, the two data inputs are operated upon and the result is output. There shall also be an OK output that is always true when the function is enabled, unless an overflow or other error exists.

All of the Arithmetic functions shall be such that they can be cascaded together in a single rung.

Relational Functions

Relation Functions which are used to compare two numbers, shall operate on Signed Integer and Double Precision Integer data types, and shall consist of the following types:

Relational Functions

Equal To	Not Equal To
Greater Than	Greater Than or Equal to
Less Than	Less Than or Equal to

Bit Operation Functions

Bit Operation Functions shall perform comparison and movement operations on word data that is specified as a continuous string of data in 16-bit increments, with the first bit of the first word being the least significant bit, and the last bit of the last word being the most significant bit.

Bit Operation Functions that are used to perform Boolean operations on corresponding bits of two bit strings of the same length shall consist of the following types:

Boolean Functions

Logical AND
Logical OR
Logical Exclusive OR

Bit Operation Functions used to create an output string that is a copy of an input bit string, but with its bits inverted, shifted, or rotated shall consist of the following types:

Bit Functions

Logical Invert (NOT)
Shift Left
Shift Right
Rotate Left
Rotate Right

The shift functions shall allow for the user to specify the number of places that the array is to be shifted as an input, and provide the state of the last bit shifted out, and a copy of the shift register as outputs.

Data Move Functions
Basic data movement capabilities shall be provided by the following list of functions:

Data Move Functions

Move
Block Move
Block Clear
Shift Register
Bit Sequencer
Range
Communications Request

The movement of data (16 bit integer or word), as individual bits, from one location to another shall be accomplished by the Move function. The user shall be able to specify the length of the move.

The Block Move function shall provide the functionality to move a block of 7 constants (integer or word) to a specified location.

The ability to fill a specified block of data (word) with zeros shall be accomplished by the Block Clear function. The user shall be able to specify the length of the block.

The Shift Register function shall provide the functionality to shift one or more data words from a reference location into a specified memory location. All of the data within the Shift Register shall be accessible throughout the program from logic addressed memory.

A method of shifting a bit sequence through an array of bits shall be provided by a Bit Sequencer function. The function shall provide the ability to reset the sequence, change the direction of the bit pattern, or access the step location within the array.

A method of checking for a value to be contained within a group of values shall be provided in a Range function.

Provisions to initiate communications with a specialized communication module shall be made through the use of a Communication Request function. This function shall allow the PLC to behave as a master on a serial communication link, thus providing the ability to communicate master/slave or peer to peer with any controller or computer using the same serial communication protocol.

Table

Table operations shall consist of moving data into or out of tables and searching for data of values equal to, not equal to, greater than, greater than or equal to, less than, and less than or equal to a specified value.

Table Functions

Array moves
Search Equal
Search Not Equal
Search Greater Than
Search Greater Than or Equal to
Search Less Than
Search Less Than or Equal to

The array move feature shall be capable of implementing indirect addressing applications.

Conversion Functions

Two conversion functions shall be provided to convert a data item from a 4 digit Binary Coded Decimal (BCD-4) data type to a 16 bit signed integer and vice versa.

Control Functions

Control functions shall be provided to limit program execution, alter the way the CPU executes the application program, or provide special PLC services. The following Control Functions shall be provided:

Control Functions

CALL
Immediate I/O update (DO I/O)
Comment rung (COMMNT)
Master Control Relay (MCR, END MCR)
Jump to a label (JUMP, LABEL)
Special Service Requests (SVCREQ)

An immediate I/O update function shall be provided for the update of all or a portion of the inputs or outputs for one scan while the program is running, or to update I/O during the program in addition to the normal I/O scan.

Additionally, the function shall provide a mean to read inputs into memory auxiliary to the true input table, and execute outputs from discrete memory alternate to the true output table.

A comment rung function shall be provided to enter a rung explanation in the program. The rung explanation shall have the capacity to hold 2048 characters of text. The memory required for the comment shall be independent of the program storage memory. The comment shall have the ability to be edited via the PC compatible programming software.

A master control relay function shall allow all rungs between the MCR and its subsequent END MCR function to be executed without power flow.

A method for structuring the ladder program shall be provided with the use of a JUMP Function. This will cause the program execution to jump to a specified location in the logic targeted by the location of the LABEL function.

Seven different special PLC service requests shall be accessible by the programmer by utilizing one of the Service Request Functions listed below:

Service Request Functions

Change/Read Checksum Task State and
Logical Number of Words to Checksum
Change/Read Time of Day Clock.
Shut Down the PLC.
Clear Fault Tables.
Read Last Fault Table Entry.
Read Elapsed time Clock.
Read I/O Override Status.

The Data written by these service request functions shall be in BCD or Packed ASCII format, and written into user definable register locations.

PID Function

A single PID function block instruction must be provided by the CPU without any additional module. Two versions of this closed loop control algorithm (Proportional/Integral/Derivative) shall be available:

The standard ISA PID algorithm, which applies the proportional gain to each of the proportional, derivative, and integral terms; and

The independent algorithm that applies the proportional gain only to the proportional gain term.

Subroutine Function

A single function block must be available to allow repetitive call of a function. A password to protect the integrity of the subroutine must also be available.

A Subroutine may be called from within another subroutine. The nesting must be at least 8 deep.

A Periodic Subroutine shall be available that is executed once a programmable interval. The interval shall be between 1 and 10 milliseconds. The accuracy of the subroutine execution shall be 50 nanoseconds. Discrete I/O shall be available to update during the execution of the subroutine.

Discrete I/O

Interface between the PLC and user supplied input and output field devices shall be provided by rack type I/O modules.

Configuration

There shall be an expandable I/O system that shall be supported by a single slot modular CPU, and shall accommodate up to 8 total racks or 79 I/O slots up to a total distance of 50 feet with the standard expansion racks and 700 feet with the remote expansion racks.

Expansion I/O racks shall be connected to the CPU rack via a high speed serial interface cable. The receiver shall be contained within the expansion baseplates eliminating the requirement for additional communication modules.

I/O Addressing

I/O reference addressing for each I/O module shall be assigned through the use of the PC compatible configuration and programming software or the hand held programmer. There shall be no jumpers or DIP switch settings required to address modules.

The circuit status of each I/O point on a module shall be indicated by a green LED mounted at the top of the module. These LED's must be visible through a clear plastic lens. Each LED shall illuminate a letter and number which corresponds to the energized I/O circuit.

Addressing of all references including I/O must be represented as a Decimal Based number.

Construction

Terminal blocks shall be easily removable, and common to all discrete and analog I/O to allow for convenient pre-wiring of field devices.

Each I/O module shall contain a hinged, clear plastic, terminal block cover (door) with a removable label.

The inside of the label shall have the module description, catalog number, and circuit wiring diagram for that module type, and the outside of the label shall have a user legend space to record circuit identification information.

The label shall have color coding for quick identification of the module as high voltage (red), low voltage (blue), or signal level (gray) type.

Electrical Specifications

I/O modules shall be designed for 1500 volt isolation between the field wiring and the system backplane.

Input Specifications

The 120 Volt AC input module shall accommodate an input voltage range from 0 to 132 volts.

The 240 Volt AC input module shall accommodate an input voltage range from 0 to 264 volts.

The 24 Volt DC positive and negative logic input modules shall accommodate an input voltage range of 0 to +30 volts DC.

The 125 Volt DC input module shall accommodate an input voltage range from 0 to 150 volts.

Availability Of Input Modules

As a minimum, the following discrete input modules shall be available:

Description	**Points/Module**
Input Simulator	8, 16
120 Vac Isolated Input	8
240 Vac Isolated Input	8
120 Vac Input	16
24 Vac/Vdc Negative Logic Input	16
24 Vdc, Positive/Negative Logic Input	8.16.32
24 Vdc Positive/Negative Logic Input, (1ms response)	16
125 Vdc Positive/Negative Logic Input	8
5/12 Vdc Positive/Negative Logic Input (TTL)	32

Output Specifications

Discrete AC output modules shall have separate and independent commons allowing each group to be used on different phases of AC supply.

Each discrete AC output shall be provided with an RC snubber to protect against transient electrical noise on the power line.

Discrete AC outputs shall be suitable for controlling a wide range of inductive and incandescent loads by providing a high degree of inrush current (10x the rated current).

Discrete DC output modules shall be available with positive and negative logic characteristics in compliance with the IEC industry standard.

Discrete DC output modules shall be provided with at least eight output points in a group with a common power input terminal per group.

Discrete DC output modules shall be compatible with a wide range of user-supplied load devices, such as: motor starters, solenoids, and indicators.

A 2 Amp relay output module shall be capable of supplying 2 Amps resistive maximum load per output and 4 amps resistive maximum load per group of 4 outputs.

A 4 Amp relay output module shall have 8 isolated outputs per module and shall be capable of supplying 4 amps resistive maximum load per output and 32 amps resistive maximum load per module.

Availability Of Output Modules

As a minimum, the following discrete output modules shall be available:

Description	**Points/Module**	**Fuse**	**# Fuses/**
		Rating	Module
120 VAC, 0.5A (2 groups)	12,16	3A	2
120/240 VAC, 1A (2 groups)	8	3A	2
120/240 VAC Isolated, 2A	5	3A	5
12/24 VDC Positive Logic, 2A	8	5A	2
12/24 VDC Positive Logic, 0.5A	8,16,32	N/A	0
12/24 VDC Negative Logic, 2A	8	5A	2
12/24 VDC Negative Logic, 0.5A	8,16	N/A	0
125 VDC Positive/Negative Logic, 1A	6	N/A	0
5/12/24 Vdc Negative Logic, 0.5A	32	N/A	0
Relay, Normally Open, 2A (4 groups)	16	N/A	0
Relay, Normally Open, 4A Isolated	8	N/A	0
Relay, Isolated, 4 Normally Closed, 4 Normally Open (Form B & C) 8A	8	N/A	0

Availability Of Mixed I/O Modules

As a minimum, the following discrete output modules shall be available:

Description	**Points/Module**
24 Vdc Input, Relay Output	8 in, 8 out
120 Vac Input, Relay Output	8 in, 8 out

Analog I/O

For the conversion of analog to digital and digital to analog conversion required by an application, the following shall be available:

Analog Voltage Input

The analog voltage input module shall be capable of converting 4 or 16 channels of inputs in the range of -10 to +10 volts.

Resolution of the converted analog voltage input signal shall be 12 bits binary or 1 part in 4096.

All of the channels of converted analog voltage input signals shall be updated each scan into a dedicated area of data registers in a 16-bit 2’s complement format.

The conversion speed for all of the analog voltage input channels shall be no less than 2 milliseconds and no greater than 13 milliseconds..

The analog voltage input module shall be configurable to a 4 to 20 mA analog current input via an external resistor.

Analog Current Input

The analog current input module shall be capable of converting 4 or 16 channels of inputs in the range of 4 to 20 mA or 0 to 20 mA.

Resolution of the converted analog current input signal shall be 12 bits binary or 1 part in 4096.

All of the channels of converted analog current put signals shall be updated each scan into a dedicated area of data registers in a 16-bit 2's complement format.

The conversion speed for all analog current input channels shall be a minimum of 2 milliseconds and no greater the 13 milliseconds.

Analog Voltage Output

The analog voltage output module shall be capable of converting 2 or 8 channels of digital data to analog outputs in the range of -10 to +10 volts.

Resolution of the converted output signal shall be 13 bits or 16 bits.

All channels of analog output data shall be updated each scan from a dedicated area of data registers in a 16-bit 2's complement format.

The analog voltage outputs shall be configurable to default to 0 mA, 4 mA or hold-last-state in the event of a CPU failure.

Analog Current Output

The analog current output module shall be capable of converting 2 or 8 channels of digital data to analog outputs in the range of 0 to 20 mA. .

Resolution of the converted output signal shall be 12 bits or 16 bits.

All channels of analog output data shall be updated each scan from a dedicated area of data registers in a 16-bit 2's complement format.

The analog current outputs shall be configurable to default to 0 volts or hold-last-state in the event of a CPU failure.

Analog Combination

The analog combo module shall be capable of converting 4 channels of analog inputs to digital data and 2 channels of digital data to analog outputs.

All channels are configurable for 0-20ma, 4-20ma, 0-+10V, and -10-+10V. Resolution of the converted input signals shall be 12 bits and output signals shall be 16 bits.

All channels of analog data shall be updated each scan from a dedicated area of data registers in a 16-bit 2's complement format.

The analog outputs shall be configurable to default to 0 volts or hold-last-state in the event of a CPU failure.

Module Availability

As a minimum, the following analog modules shall be available:

Description	**Channels/Module**
Input	4, 16
Voltage Analog Input	4, 16
Current Analog Output	2, 8
Voltage Analog Output	2, 8
Combo Analog Inputs/Outputs	4/2

Temperature Control Module

A specialized temperature control module shall be available to accommodate applications where precise temperature control is needed.

The temperature control module shall support auto-tuning, closed looped PID control, and open looped manual control.

The temperature control module shall provide eight thermocouple inputs, 1 RTD input, and 8 PID-controlled output channels for controlling heaters.

The temperature control module shall provide alarms indications for each status zone, voltage failure, open or reversed thermocouple, compensation temperature error, high or low temperature, high or low temperature deviation, and open channel short circuit.

Motion Control

Specialized analog and digital motion control modules shall be available to perform 1 or 2 axes of closed or open loop servo control. These modules shall support encoder feedback with analog output for velocity command.

The positioning mode shall support linear and S curve acceleration and deceleration.

The modules shall provide user-defined control inputs and outputs for application such as torque follower and flying cut-off applications.

The modules must have user defined inputs and outputs, an English-language programming software, and automatic data transfer of data between PLC and axis positioning module with no user programming.

The positioning mode shall have a powerful instruction set, that includes absolute or incremental move, wait to move, dwell, conditional jump and subroutine functions.

The modules shall provide non-volatile program storage without the use of battery or super capacitor.

The follower mode shall provide either parallel or cascade operation from a single master.

The follower mode shall provide a selectable master source of encoder, analog, or internal time base.

The single axis module shall have a position loop update time of not more than 1 msec. The dual axis module shall have a position loop update time of not more than 2 msec. per axis.

High Speed Counter

A specialized high speed counter option module shall be available to accommodate applications where pulse input rates exceed the input capability of the PLC.

The high speed counter module shall provide direct processing of rapid pulse signals up to 80 KHz in frequency.

The high speed counter module shall be configurable as four independent counters counting either up or down, two independent bi-directional counters, or one counter that can calculate the difference between two changing count values.

Programmable Coprocessor Module

A specialized high-performance programmable microcomputer module having up to 640 KBytes of on-board CMOS battery-backed user memory shall be available to perform coprocessor functions.

The specialized coprocessor module shall be programmable with a powerful BASIC language interpreter or ‘C’ Language to perform data acquisition, data storage and retrieval, real time computing, and operator interface functions.

The specialized coprocessor module shall be capable of performing master/slave or peer-to-peer serial communication tasks in point to point or multidrop configurations utilizing a serial communication protocol.

The configurable module shall have two serial communication ports, one RS-232 and the other a selectable RS232 or RS-485. It shall have dual tasking capabilities, and shall be software configurable to behave as:

One serial communication port,
Two independent serial communication ports,
One serial communication port and one ASCII/BASIC application using one port, or
One ASCII/BASIC application using one or both ports.

Specialty I/O And Communications

Based on open architecture specifications of the vendor and explicit permission of the vendor, specialty module shall be available such as PID, Co-processor, stepper, etc.

Complete documentation, kits for building modules, and engineering resource shall be available for the 3rd party based on the type of development.

Peer/Peer Communications

A specialized option module shall be available that will allow the PLC to communicate on a token passing peer-to-peer, noise immune network providing high-speed transfer of control data.

The specialized communication module shall be configurable to broadcast data to and receive data from up to 31 other devices on a network automatically and repeatedly from a shared and dedicated database in RAM memory.

The communication medium for this specialized network shall be a high energy and noise immune single shielded twisted pair cable transmitting data at an adjustable rate of up to 153.6 Kbaud. The distance of the communication shall be up to 7500 ft at a lower baud rate.

Master/Slave Communications

There shall be modules (such as a Modbus RTU protocol module as specified elsewhere in these special provisions) that allows the PLC to act as a master in a communication scheme that allows the PLC to interrogate other PLCs and devices for data.

PLC And CNC I/O Interface

The I/O Interface shall provide an interface between the PLC and a CNC, allowing a CNC to control 64 I/O points on the PLC.

Client/Server Interface

There shall be a module that provides CLIENT/SERVER with PEER to PEER communications over Ethernet TCPIP.

The modular CPU system and special module shall support up to 16 simultaneous connections.

FSK Modem

The format of the FSK Modem shall be Standard RS233C with four-wire operation for long range up to 12.2 km. Mode of operation will be point-to-point of multi-drop. Data transmission speed shall be up to 9600 baud. Modulation shall be frequency shift key (FSK); carrier signal transformer and capacitively isolated. Interface shall be DTE/DCE jumper selectable; Female DB25 connector for RS232C; two position pluggable terminal block for carrier; 2.5 mm x 5.5mm barrel jack (center positive) for 24VDC. Power shall be 21 to 28 VDC or 120VAC with wall mounted transformer. The FSK modem shall be designed for a temperature range of 0-60 degrees C and humidity of 0 to 95%, non-condensing. Enclosure shall be 16-gauge steel with mounting flanges.

Modbus RTU Master Modules

The RTU Master Modules shall support the Modbus protocol and shall be compatible with the CPU. The RTU Master Modules shall be flexible with both RS-232(direct) and RS-485 (multidrop) ports with the capability of simultaneous communications on up to two ports. The two Modbus/RTU channels provided shall be controlled by the CPU to access data from remote field devices. Each channel shall be individually programmed for dial in, dial out, radio, multi-drop (RS-485) and direct (RS-232) operation. Each channel shall be able to send or receive Analog or Discrete data using standard RTU commands (i.e. Read Coil). Multiple commands can be sent to each slave with each command requesting either single point or multiple continuous points up to 250 bytes. Data to be sent or stored shall be placed in the CPU reference data tables. The module shall function as a master and allow data to be read/written up to 32 slaves and support RTU mode (binary) and Modbus mode (ASCII). Port connections shall be made to a single 25-pin connector, with a pinout that provides RS-232 signals for port one, and RS-232 and RS-485 signals for port two. A "Y" cable that separates port one signals from port two shall be included. Three LEDs visible through the front of the module shall provide module status and port status. Report by exception shall be supported by the module provided.

INSTALLATION REQUIREMENTS

Four Remote Terminal Units (RTUs) shall be installed by Contractor. The RTU's are to be installed and wired as shown on the plans.

The Contractor shall be responsible for making a complete, operational loop check of each circuit installed by the Contractor and connected to the input and output terminals of the RTU. Loop checks shall be performed by simulating a contact closure as necessary to prove the operation of each circuit. The complete functional check including the SCADA Master PLC and workstations shall be performed under different contracts.

ENGINEER'S ESTIMATE
04-01250F4
ALTERNATIVE 1

Item	Item Code	Item	Unit of Measure	Estimated Quantity	Unit Price	Item Total
41	203021	FIBER ROLLS	M	252		
42	203024	COMPOST (EROSION CONTROL)	KG	470		
43	030711	MOVE IN/OUT (EROSION CONTROL)	EA	4		
44	203045	PURE LIVE SEED (EROSION CONTROL)	KG	30		
45 (S)	049299	EPOXY ASPHALT CONCRETE AGGREGATE	TONN	3670		
46 (S)	049300	EPOXY ASPHALT BOND COAT AND BINDER	KG	268 000		
47 (S)	049301	APPLY EPOXY ASPHALT BOND COAT	M2	32 800		
48 (S)	049302	PLACE EPOXY ASPHALT CONCRETE SURFACING	M2	32 800		
49 (S)	049303	PRESTRESSING CAST-IN-PLACE CONCRETE (PIER W2)	LS	LUMP SUM	LUMP SUM	
50 (S)	049304	PRESTRESSING CAST-IN-PLACE CONCRETE (PIER E2)	LS	LUMP SUM	LUMP SUM	
51 (S)	049305	HIGH STRENGTH PRESTRESSING ROD (75 MM)	LS	LUMP SUM	LUMP SUM	
52 (S)	049306	CABLE TIEDOWN	LS	LUMP SUM	LUMP SUM	
53 (F)	510053	STRUCTURAL CONCRETE, BRIDGE	M3	8200		
54 (F)	049307	STRUCTURAL CONCRETE, FENDER	M3	1204		
55 (F)	049308	MINOR CONCRETE (COUNTERWEIGHT)	M3	430		
56 (S-F)	049309	FURNISH POLYESTER CONCRETE OVERLAY (13 MM)	M3	40		
57 (S-F)	049310	PLACE POLYESTER CONCRETE OVERLAY (13 MM)	M2	3050		
58 (S)	049311	FURNISH AND INSTALL SPHERICAL BUSHING BEARING (PIER E2)	EA	4		
59 (S)	049312	FURNISH SPHERICAL BUSHING RING BEARING (HINGE K)	EA	4		
60 (S)	049313	INSTALL CIRCULAR SEGMENTED BEARING (HINGE A)	EA	16		

ENGINEER'S ESTIMATE
04-01250F4
ALTERNATIVE 2

Item	Item Code	Item	Unit of Measure	Estimated Quantity	Unit Price	Item Total
41	203021	FIBER ROLLS	M	252		
42	203024	COMPOST (EROSION CONTROL)	KG	470		
43	030711	MOVE IN/OUT (EROSION CONTROL)	EA	4		
44	203045	PURE LIVE SEED (EROSION CONTROL)	KG	30		
45 (S)	049299	EPOXY ASPHALT CONCRETE AGGREGATE	TONN	3670		
46 (S)	049300	EPOXY ASPHALT BOND COAT AND BINDER	KG	268 000		
47 (S)	049301	APPLY EPOXY ASPHALT BOND COAT	M2	32 800		
48 (S)	049302	PLACE EPOXY ASPHALT CONCRETE SURFACING	M2	32 800		
49 (S)	049303	PRESTRESSING CAST-IN-PLACE CONCRETE (PIER W2)	LS	LUMP SUM	LUMP SUM	
50 (S)	049304	PRESTRESSING CAST-IN-PLACE CONCRETE (PIER E2)	LS	LUMP SUM	LUMP SUM	
51 (S)	049305	HIGH STRENGTH PRESTRESSING ROD (75 MM)	LS	LUMP SUM	LUMP SUM	
52 (S)	049306	CABLE TIEDOWN	LS	LUMP SUM	LUMP SUM	
53 (F)	510053	STRUCTURAL CONCRETE, BRIDGE	M3	8200		
54 (F)	049307	STRUCTURAL CONCRETE, FENDER	M3	1204		
55 (F)	049308	MINOR CONCRETE (COUNTERWEIGHT)	M3	430		
56 (S-F)	049309	FURNISH POLYESTER CONCRETE OVERLAY (13 MM)	M3	40		
57 (S-F)	049310	PLACE POLYESTER CONCRETE OVERLAY (13 MM)	M2	3050		
58 (S)	049311	FURNISH AND INSTALL SPHERICAL BUSHING BEARING (PIER E2)	EA	4		
59 (S)	049312	FURNISH SPHERICAL BUSHING RING BEARING (HINGE K)	EA	4		
60 (S)	049313	INSTALL CIRCULAR SEGMENTED BEARING (HINGE A)	EA	16		